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

The following file is part of the

James Doyle Sell Mining Collection

**ACCESS STATEMENT**

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

**CONSTRAINTS STATEMENT**

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

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

**QUALITY STATEMENT**

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

JDS

**ASARCO**

Southwestern Exploration Division

April 27, 1990

J.D. Sell

"B" Zone Assay Comparison
RDH vs. DDH Holes
Yarnell Project
Yavapai County, Arizona

As you are aware, we have split and assayed all the core from the four diamond drill holes. The attached tables and histograms attempt to show the relationship in the assay results with both methods of drilling. The data used is "B" zone only. As one can see from the attached tables, there is sometimes considerable variation within the assay intervals even with multiple assays. Variation is shown by plotting the plus (+) or minus (-) change of the RC hole values from the corresponding DDH values.

Several observations can be made from the histograms:

1. The data does not appear to be skewed one way or another. There appears to be equal amounts of plus values as minus values suggesting that drilling techniques do not bias the assays.

2. The largest net difference appears to occur in the higher grade zone suggesting a possible nugget effect.

3. The lag in sample position that occurs in RC drilling may cause a difference in position of the RC samples compared to the diamond drill sample.

4. The difference in position of the holes relative to each other and relative to the ore zone may influence the comparison. Holes 1 and 4 are drilled ~10' updip of the RC hole. Hole 2 is ~10' NE of the RC hole. Hole 3 is 25' NE of the RC hole.

Comparing the entire assay interval (B zone) the results are as follows:

| DDH HOLES (in opt) | RC HOLES (in opt) |
|---|---|
| YDDH-1 | YM-8 |
| 0.041 | 0.041 |
| YDDH-2 | YM-40 |
| 0.070 | 0.062 |
| YDDH-3 | |
| Invalid due to stope intersection and loss of sample. | |
| YDDH-4 | YM-75 |
| 0.056 | 0.066 |

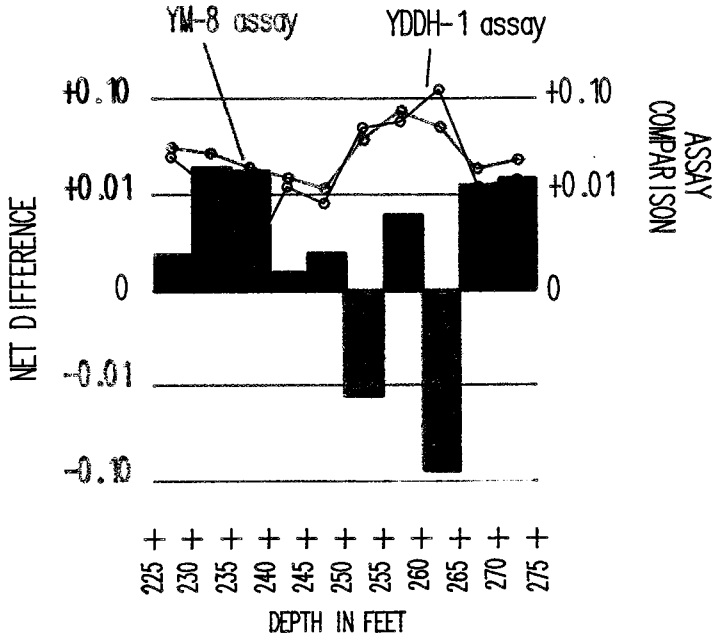
As discussed, DDH results show a fair correlation with the RC holes, but significant differences occur between individual assays.

This study seems to indicate that the RC drilling is reporting the accurate values of the intercept, and does not appear to high grade or low grade the sample. As can be seen from the tables, assay values do show repeatability within a sample interval, but variance does occur; possibly due to a nugget effect.

Mark A. Miller

MAM:mek
Att.

cc: W.L. Kurtz




**ASARCO Incorporated**
**YARNELL PROJECT**

**RCH-DDH ASSAY COMPARISONS**
**YDDH-1 vs YM-8**

**YAVAPAI CO., ARIZONA**

mn 6947MAM/dam tuc 04-27-90
file YAR- 6947dwg

"B" Zone Assay Comparison
RDH vs. DDH Holes
Yarnell Project

April 27, 1990

YDDH-1/YM-8
B-Zone Only

B Zone 50'

| Interval (ft.) | YM-8 (opt Au) | YDDH-1 (opt Au) | Net Difference |
|---|---|---|---|
| 225-230 | .047 | .043 | +.004 |
| 230-235 | .044 | .013 | +.031 |
| 235-240 | .029 | .003 | +.026 |
| 240-245 | .018 | .016 | +.002 |
| 245-250 | .013 | .009 | +.004 |
| 250-255 | .048 | .065 | -.017 |
| 255-260 | .087 | .079 | +.008 |
| 260-265 | .063 | .153 | -.090 |
| 265-270 | .023 | .012 | +.011 |
| 270-275 | .037 | .019 | +.018 |
| Composite Assay 225-275 (in opt Au) | .041 | .041 | |

# BULK ASSAY REPORT

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

DATE 1-4-90

COMPANY ASARCO LAB #122889-1

DRILL CORE

PAGE 1

| Sample Description | Ounces per ton AU (gold) | AG (silver) | Remarks |
|---|---|---|---|
| YDDH-1 4-5 | .001 | | |
| " " 5-10 | .006 | | |
| " " 10-15 | .003 | | |
| " " 15-20 | .008 | | |
| " " 17-19 | .009 | | |
| " " 20-25 | .001 | | |
| " " 25-30 | .004 | | |
| " " 30-35 | .001 | | |
| " " 35-36 | .012 | | |
| " " 36-37 | .034 | | |
| " " 37-38 | .134 | | |
| " " 37-39 | .075 | | |
| " " 38-39 | .108 | | |
| " " 39-40 | .195 | | |
| " " 40-41 | .108 | | |
| " " 45-50 | .125 | | |
| " " 50-55 | .015 | | |
| " " 57-59 | .003 | | |
| " " 55-60 | .003 | | |
| " " 60-65 | .002 | | |
| " " 65-70 | .015 | | |
| " " 70-75 | .010 | | |
| " " 77-79 | .018 | | |

Certified Assays When Signed And Dated
1-4-90 [signature]
DATE SIGNATURE

# BULK ASSAY REPORT

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

DATE 1-4-90

COMPANY ASARCO LAB #122889-2

DRILL CORE

PAGE 2

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH-1 75-80 | .019 | | |
| " " 80-85 | .008 | | |
| " " 85-90 | .012 | | |
| " " 90-95 | .013 | | |
| " " 97-99 | .006 | | |
| " " 95-100 | .002 | | |
| " " 100-105 | .001 | | |
| " " 105-110 | .006 | | |
| " " 110-115 | .001 | | |
| " " 115-120 | .039 | | |
| " " 117-119 | .014 | | |
| " " 120-125 | .050 | | |
| " " 125-130 | .004 | | |
| " " 130-135 | NO SAMPLE | | |
| " " 135-140 | .013 | | |
| " " 137-139 | .011 | | |
| " " 140-145 | .020 | | |
| " " 145-150 | .011 | | |
| " " 150-155 | .010 | | |
| " " 155-160 | .021 | | |
| " " 157-159 | .033 | | |
| " " 160-165 | .058 | | |
| " " 165-170 | .016 | | |
| " " 170-175 | .017 | | |

Certified Assays When Signed And Dated
1-11-90
DATE SIGNATURE

# BULK ASSAY REPORT

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

DATE 1-4-90

COMPANY ASARCO LAB #122889-3

DRILL CORE

PAGE 3

| Sample Description | Ounces per ton AU (gold) | AG (silver) | Remarks |
|---|---|---|---|
| YDDH-1 177-179 | .021 | | |
| " " 175-180 | .008 | | |
| " " 180-185 | .023 | | |
| " " 185-190 | .019 | | |
| " " 190-195 | .017 | | |
| " " 195-200 | .067 | | |
| " " 197-199 | .018 | | |
| " " 200-205 | .013 | | |
| " " 205-210 | .029 | | |
| " " 210-215 | .061 | | |
| " " 217-219 | .017 | | |
| " " 215-220 | .020 | | |
| " " 220-225 | .017 | | |
| " " 225-230 | .043 | | |
| " " 227-229 | .056 | | |
| " " 230-235 | .013 | | |
| " " 235-240 | .003 | | |
| " " 237-239 | .024 | | |
| " " 240-245 | .016 | | |
| " " 242-244 | .017 | | |
| " " 245-250 | .009 | | |
| " " 247-249 | .009 | | |
| " " 250-255 | .065 | | |
| " " 252-254 | .056 | | |

Certified Assays When Signed And Dated
1-4-90 [signature]
DATE SIGNATURE

# BULK ASSAY REPORT

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

DATE 1-4-90

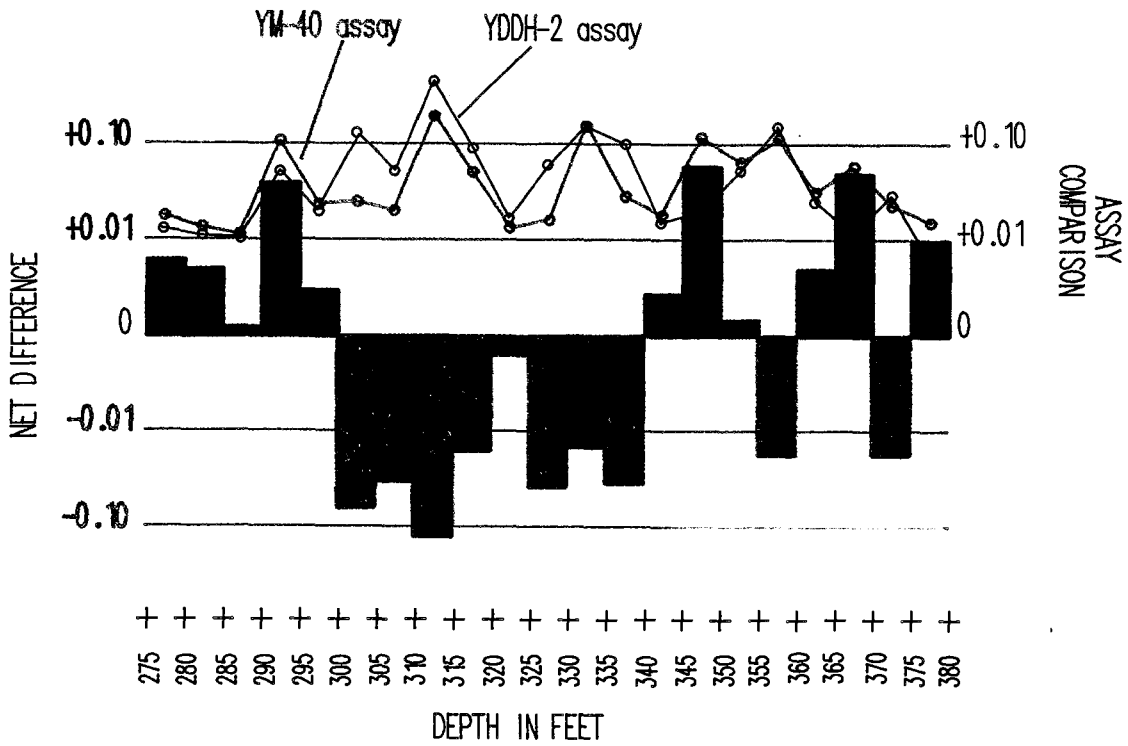
COMPANY ASARCO LAB #122889-4

DRILL CORE

PAGE 4

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH-1 255-260 | .079 | | |
| " " 257-259 | .111 | | |
| " " 260-265 | .153 | | |
| " " 262-264 | .084 | | |
| " " 265-270 | .012 | | |
| " " 267-269 | .023 | | |
| " " 270-275 | .019 | | |
| " " 272-274 | .028 | | |
| " " 275-280 | .002 | | |
| " " 280-285 | .004 | | |
| " " 285-290 | .002 | | |
| " " 290-295 | .002 | | |
| " " 295-300 | TR | | |
| " " 300-305 | .001 | | |
| " " 305-310 | .001 | | |
| " " 310-315 | TR | | |
| " " 315-320 | TR | | |
| " " 320-325 | NIL | | |
| " " 325-330 | TR | | |
| " " 330-335 | TR | | |
| " " 335-340 | NIL | | |
| " " 340-345 | .001 | | |
| " " 345-350 | TR | | |

Certified Assays When Signed And Dated
1-4-90
DATE SIGNATURE




**ASARCO Incorporated**
**YARNELL PROJECT**

**RCH-DDH ASSAY COMPARISONS**
**YDDH-2 vs YM-40**

**YAVAPAI CO., ARIZONA**

mn 6945 MAM/dam tuc 04-27-90
file YAR- 6945dwg

"B" Zone Assay Comparison
RDH vs. DDH Holes
Yarnell Project

April 27, 1990

YDDH-2/YM-40
B-Zone Only

B Zone 105'

| Interval (ft.) | YM-40 | 1G | RC Checks YDDH-2 | DD Hole YDDH-2 | Net Difference |
|---|---|---|---|---|---|
| 275-280 | .023 | .030 | .019 | .015 | +.008 |
| 280-285 | .018 | .020 | .017 | .011 | +.007 |
| 285-290 | .012 | .023 | .095 | .011 | +.001 |
| 290-295 | .129 | .123 | .072 | .067 | +.062 |
| 295-300 | .036 | .045 | .039 | .031 | +.005 |
| 300-305 | .041 | .046 | .080 | .122 | -.081 |
| 305-310 | .027 | .046 | .033 | .077 | -.050 |
| 310-315 | .177 | .168 | .053 | .320 | -.143 |
| 315-320 | .071 | .096 | .091 | .091 | -.020 |
| 320-325 | .013 | .016 | .016 | .015 | -.002 |
| 325-330 | .021 | .045 | .048 | .079 | -.058 |
| 330-335 | .162 | .119 | .544 | .174 | -.012 |
| 335-340 | .043 | .056 | .056 | .099 | -.056 |
| 340-345 | .034 | .046 | .090 | .029 | +.005 |
| 345-350 | .108 | .142* | -- | .029 | +.079 |
| 350-355 | .081 | .108* | -- | .082 | -.001 |
| 355-360 | .131 | .069 | .053 | .152 | -.021 |
| 360-365 | .043 | .042 | .051 | .036 | +.007 |
| 365-370 | .079 | .063 | .077 | .013 | +.066 |
| 370-375 | .033 | .063 | .042 | .046 | -.013 |
| 375-380 | .018 | .026 | .011 | .008 | +.010 |
| Composite Assays 275-380 (in opt Au) | .062 | .066 | .080 | .070 | |

*(pulps)

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-14-90

**COMPANY** ASARCO LAB #031390-1

ROTARY CUTTINGS

PAGE 1

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 2 0-4 | .019 | | |
| " " 4-9 | .017 | | |
| " " 9-14 | .095 | | |
| " " 14-19 | .072 | | |
| " " 19-24 | .039 | | |
| " " 24-29 | .080 | | |
| " " 29-34 | .033 | | |
| " " 34-39 | .053 | | |
| " " 39-44 | .091 | | |
| " " 44-49 | .016 | | |
| " " 49-54 | .048 | | |
| " " 54-59 | .544 | | |
| " " 59-64 | .056 | | |
| " " 64-69 | .090 | | |
| " " 69-74 | .053 | | |
| " " 74-79 | .051 | | |
| " " 79-84 | .077 | | |
| " " 84-89 | .042 | | |
| " " 89-94 | .011 | | |
| " " 254-259 | .006 | | |
| " " 255-260 | .004 | | |
| " " 259-264 | .010 | | |
| " " 260-265 | .003 | | |
| " " 264-269 | .002 | | |
| " " 265-270 | .003 | | |

Certified Assays When Signed And Dated

3-14-90 DATE

SIGNATURE

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-14-90

**COMPANY** ASARCO LAB #031390-2

ROTARY CUTTINGS

PAGE 2

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 2 269-274 | .005 | | |
| " " 270-275 | .003 | | |
| " " 275-280 | .015 | | |
| " " 280-285 | .011 | | |
| " " 285-290 | .011 | | |
| " " 290-295 | .067 | | |
| " " 295-300 | .031 | | |
| " " 300-305 | .122 | | |
| " " 305-310 | .077 | | |
| " " 310-315 | .320 | | |
| " " 315-320 | .091 | | |
| " " 320-325 | .015 | | |
| " " 325-330 | .079 | | |
| " " 330-335 | .174 | | |
| " " 335-340 | .099 | | |
| " " 340-345 | .079 | | |
| " " 345-350 | .029 | | |
| " " 350-355 | .082 | | |
| " " 355-360 | .152 | | |
| " " 360-365 | .036 | | |
| " " 365-370 | .013 | | |
| " " 370-375 | .046 | | |
| " " 375-380 | .008 | | |
| " " 380-385 | .004 | | |
| " " 385-390 | .003 | | |

Certified Assays When Signed And Dated
3-14-90
DATE SIGNATURE

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-14-90

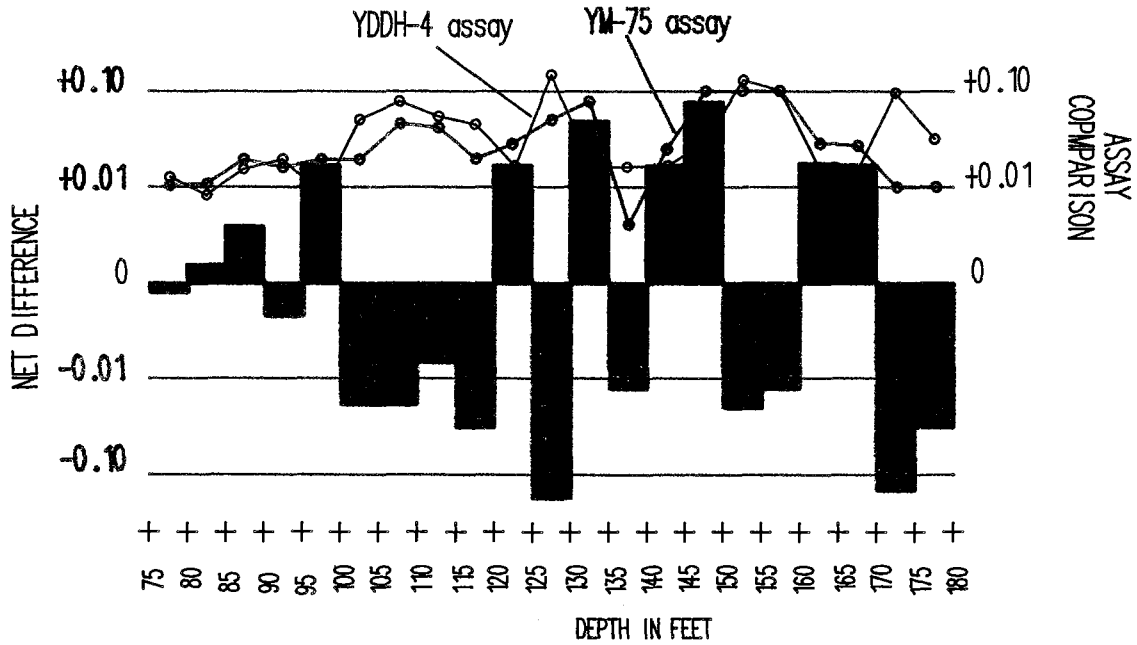
**COMPANY** ASARCO LAB #031390-3

ROTARY CUTTINGS

PAGE 3

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 2 390-395 | .004 | | |
| " " 395-400 | .007 | | |
| | | | |
| YDDH - 3 124-129 | .010 | | |
| " " 125-130 | .003 | | |
| " " 129-134 | .014 | | |
| " " 130-135 | .045 | | |
| " " 134-139 | .011 | | |
| " " 135-140 | .024 | | |
| " " 139-144 | .039 | | |
| " " 140-145 | .020 | | |
| " " 144-149 | .009 | | |

Certified Assays When Signed And Dated
3-14-90 Greg R Eddleman
DATE SIGNATURE




**ASARCO Incorporated**
**YARNELL PROJECT**

**RCH-DDH ASSAY COMPARISONS**
**YDDH-4 vs YM-75**

**YAVAPAI CO., ARIZONA**

mn 6946 MAM/dam tuc 04-27-90
file YAR- 6946dwg

"B" Zone Assay Comparison
RDH vs. DDH Holes
Yarnell Project

April 27, 1990

YDDH-4/YM-75
B-Zone Only

| Interval ( ft.) | YM-75 | | RC Checks YDDH-4 | | DDH YDDH-4 | Net Difference |
|---|---|---|---|---|---|---|
| 75-80 | .011 | -.001 | .010 | -.002 | .012 | -.001 |
| 80-85 | .011 | +.000 | .011 | +.002 | .009 | +.002 |
| 85-90 | .026 | +.021 | .047 | +.027 | .020 | +.006 |
| 90-95 | .021 | +.010 | .031 | +.006 | .025 | -.004 |
| 95-100 | .035 | +.013 | .048 | +.039 | .009 | +.026 |
| 100-105 | .037 | +.011 | .048 | -.023 | .071 | -.034 |
| 105-110 | .062 | +.011 | .073 | -.022 | .095 | -.033 |
| 110-115 | .064 | -.036 | .028 | -.048 | .076 | -.012 |
| 115-120 | .024 | +.055 | .079 | +.012 | .067 | -.043 |
| 120-125 | .047 | +.009 | .056 | +.035 | .021 | +.026 |
| 125-130 | .067 | +.009 | .076 | -.114 | .190 | -.123 |
| 130-135 | .088 | -.080 | .008 | -.013 | .021 | +.067 |
| 135-140 | .006 | +.183 | .189 | +.165 | .024 | -.018 |
| 140-145 | .043 | +.003 | .046 | +.024 | .022 | +.021 |
| 145-150 | .138 | -.033 | .105 | +.060 | .045 | +.093 |
| 150-155 | .118 | -.015 | .103 | -.052 | .155 | -.037 |
| 155-160 | .110 | -.007 | .103 | -.022 | .125 | -.015 |
| 160-165 | .051 | +.010 | .061 | +.041 | .020 | +.031 |
| 165-170 | .045 | +.012 | .057 | +.039 | .018 | +.027 |
| 170-175 | .010 | -.005 | .005 | -.106 | .111 | -.110 |
| 175-180 | .010 | -.006 | .004 | -.043 | .047 | -.046 |
| Avg | .982/17= .058 | | 1.158/17= .068 | | ~~1.004/17=~~ ~~.059~~ 1.117/17 .066 | |
| Composite Assays 105-170 (in opt Au) | .066 | | .057 | | .056 | |

B Zone 85-170

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-16-90

**COMPANY** ASARCO LAB #031590-1

DRILL CORE

PAGE 1

| Sample Description | Ounces per ton AU (gold) | AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 4 139-144 | .046 | | |
| " " 140-145 | .022 | | |
| " " 144-149 | .105 | | |
| " " 145-150 | .045 | | |
| " " 149-154 | .103 | | |
| " " 150-155 | .155 | | |
| " " 154-159 | .103 | | |
| " " 155-160 | .125 | | |
| " " 159-164 | .061 | | |
| " " 160-165 | .020 | | |
| " " 164-169 | .057 | | |
| " " 165-170 | .018 | | |
| " " 169-174 | .005 | | |
| " " 170-175 | .111 | | |
| " " 174-179 | .004 | | |
| " " 175-180 | .047 | | |
| YDDH - 2 54-59 | .368 | REFIRE | |

Certified Assays When Signed And Dated

3-16-90 [signature]

DATE SIGNATURE

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-15-90

**COMPANY** ASARCO LAB #031490-2

DRILL CORE

PAGE 2

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 3 225-230 | .095 | | |
| " " 229-234 | .036 | | |
| " " 230-235 | .019 | | |
| " " 234-239 | .044 | | |
| " " 235-240 | .008 | | |
| " " 240-245 | .038 | | |
| " " 245-250 | .110 | | |
| " " 250-255 | .012 | | |
| " " 255-260 | .004 | | |
| " " 260-265 | .004 | | |
| " " 265-270 | .008 | | |
| " " 270-275 | .004 | | |
| " " 275-280 | .015 | | |
| | | | |
| YDDH - 4 74-79 | .010 | | |
| " " 75-80 | .012 | | |
| " " 79-84 | .011 | | |
| " " 80-85 | .009 | | |
| " " 84-89 | .047 | | |
| " " 85-90 | .020 | | |
| " " 89-94 | .031 | | |
| " " 90-95 | .025 | | |
| " " 94-99 | .048 | | |
| " " 95-100 | .009 | | |
| | | | |

Certified Assays When Signed And Dated
3-16-90
DATE SIGNATURE

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-15-90

**COMPANY** ASARCO LAB # 031490-3

DRILL CORE

PAGE 3

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 4 99-104 | .048 | | |
| " " 100-105 | .071 | | |
| " " 104-109 | .073 | | |
| " " 105-110 | .095 | | |
| " " 109-114 | .028 | | |
| " " 110-115 | .076 | | |
| " " 114-119 | .079 | | |
| " " 115-120 | .067 | | |
| " " 119-124 | .056 | | |
| " " 120-125 | .021 | | |
| " " 124-129 | .076 | | |
| " " 125-130 | .190 | | |
| " " 129-134 | .008 | | |
| " " 130-135 | .021 | | |
| " " 134-139 | .189 | | |
| " " 135-140 | .024 | | |

Certified Assays When Signed And Dated

3-18-90 [signature]
DATE SIGNATURE

JDS

**ASARCO**

**Southwestern Exploration Division**

April 27, 1990

J.D. Sell

Alvarado Mine
Conquistador Gold
Yavapai County, AZ

During the meeting in Reno, I met with Raul Madrid who along with Ralph Roberts is co-president of Conquistador Gold. They currently have control of the Alvarado Mine property which is southwest of the Yarnell Mine area. Conquistador Gold has recently completed some trenching on the property which looks interesting (attached). According to their data, they show additional mineralization which is found in the hanging wall and footwall of the vein structures. They have also identified additional veins parallel to the main Alvarado vein. Their sampling suggests that there is additional mineralization as most of their trenches end in mineralized rock.

Madrid also said that the Alvarado and the Yarnell structure are the same: only offset by a cross fault. I don't think that this is right, as the Yarnell Fault can be traced from the mine area fairly continuously to the southwest past the overlook. (This would put the Alvarado structure in the footwall of the Yarnell Fault.)

Anyway, the mineralization that they are finding is interesting and I recommend that we do additional sampling to see if the zone can be widened. Several logistical problems may exist. The ore zone is dipping to the NW which will project under the Yarnell grade highway and the stripping will increase considerably to the NW. The zone may be open to the SW under the pediment cover.

This was suggested in memo to MAM by WLK & JDS on May 10, 1989

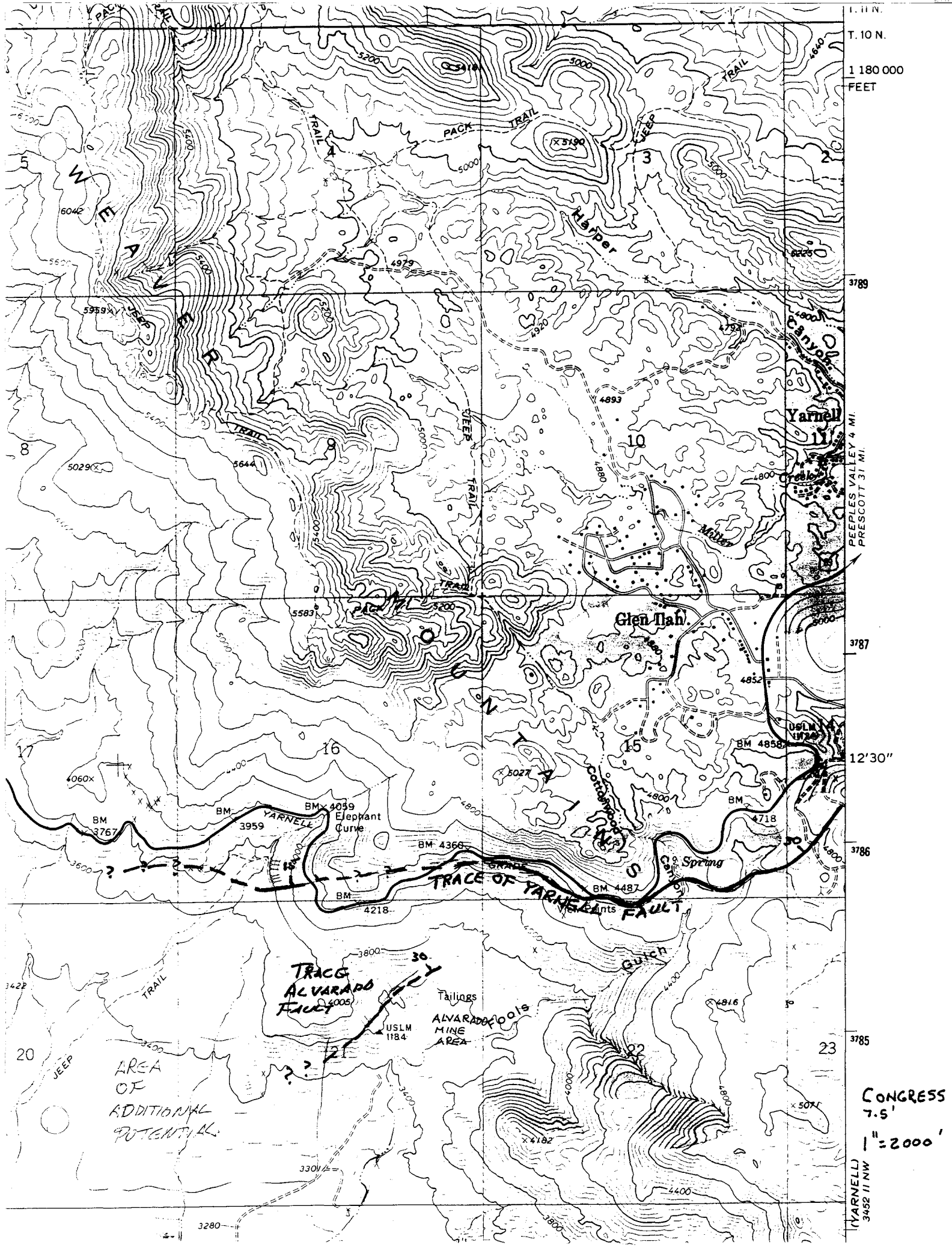
Also is in line of MAM List of Study for greater Yarnell

JDS

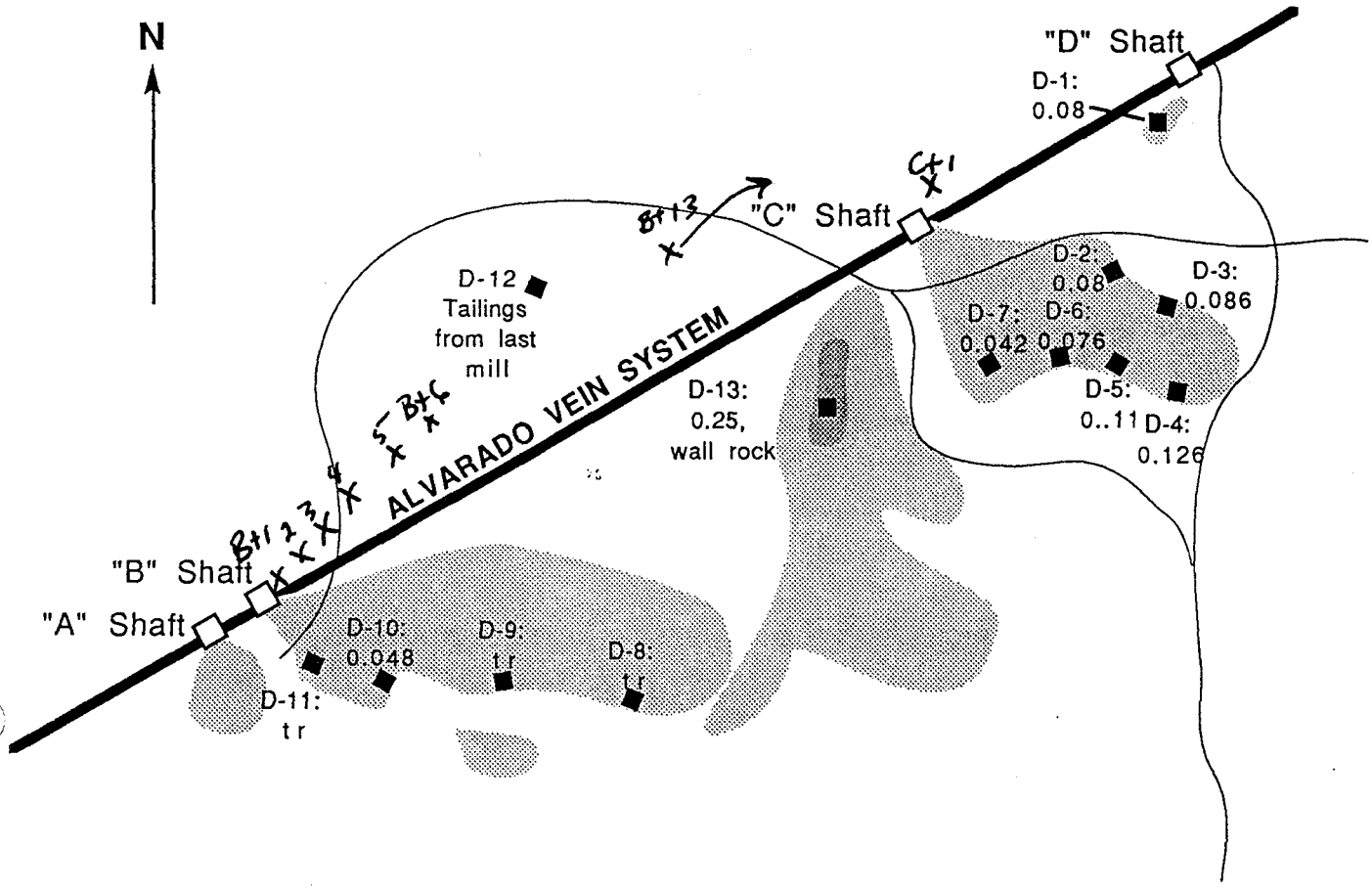
Mark A. Miller

MAM:mek

CC: W.L. Kurtz


T. 11 N.
T. 10 N.
1 180 000
FEET
3789
3787
3786
3785
12'30"
PACK TRAIL
JEEP TRAIL
Harper
Canyon
Yarnell
Creek
Miller
PEEPLES VALLEY 4 MI.
PRESCOTT 31 MI.
Glen Ilah
Cottonwood
Canyon
Spring
Elephant Curve
YARNELL
TRACE OF YARNELL FAULT
Gulch
Tailings
ALVARADO MINE AREA
TRACE ALVARADO FAULT
AREA OF ADDITIONAL POTENTIAL
CONGRESS 7.5'
1" = 2000'
(YARNELL) 3452 II NW

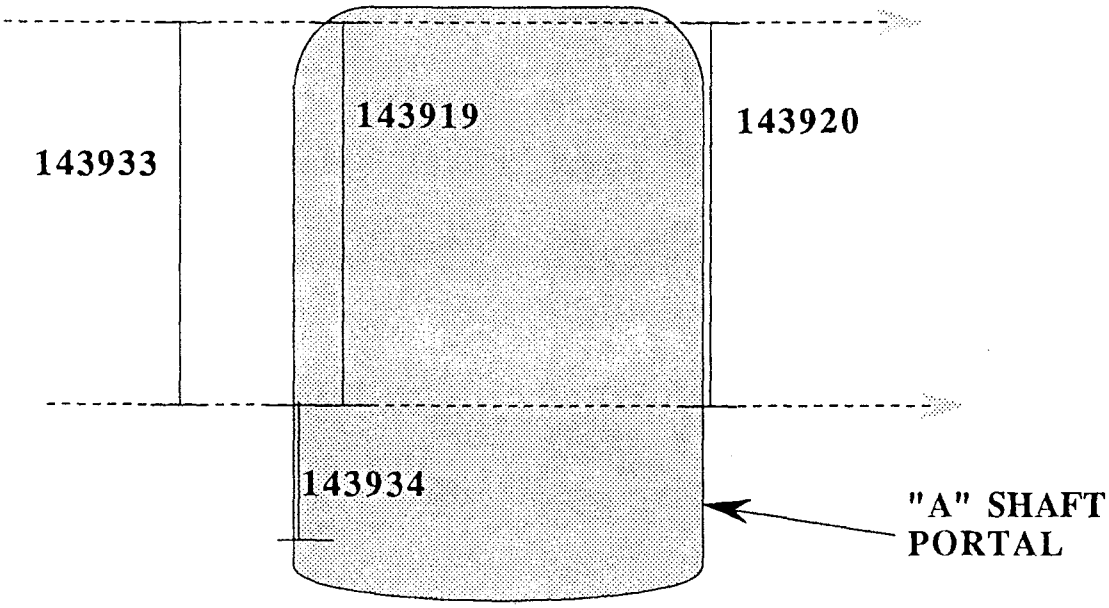
# ALVARADO DUMP SAMPLES

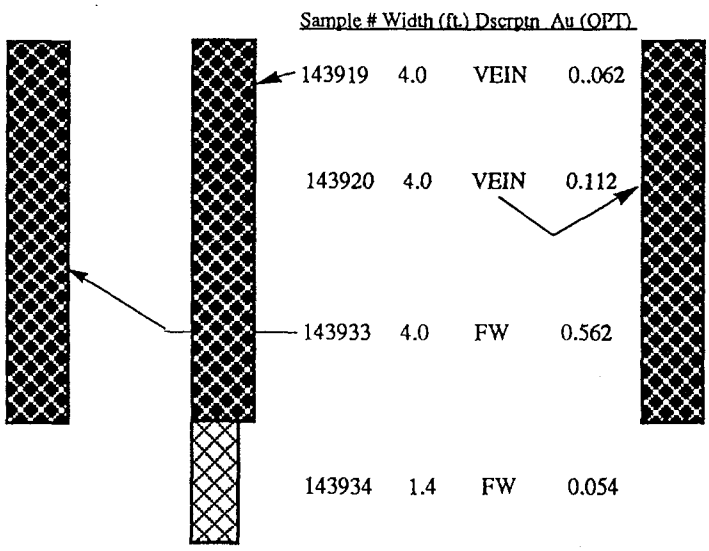



CONQUISTADOR GOLD LTD

1" = 200'?

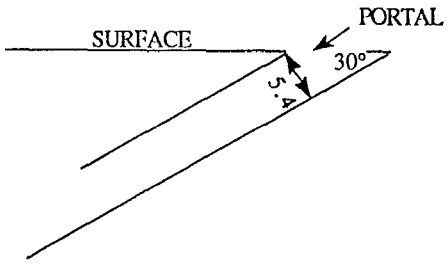
# ALVARADO, "A" SHAFT COLLAR



| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143919 | 4.0 | VEIN | 0..062 |
| 143920 | 4.0 | VEIN | 0.112 |
| 143933 | 4.0 | FW | 0.562 |
| 143934 | 1.4 | FW | 0.054 |

N68E:
STRIKE OF VEIN SYSTEM →

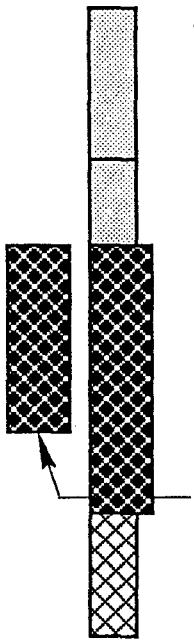



**TRUE THICKNESS PERPENDICULAR TO VEIN IS THE WEIGHTED AVERAGE OF 5.4 FEET @ 0.225 OPT AU**

*CONQUISTADOR GOLD/MCO*

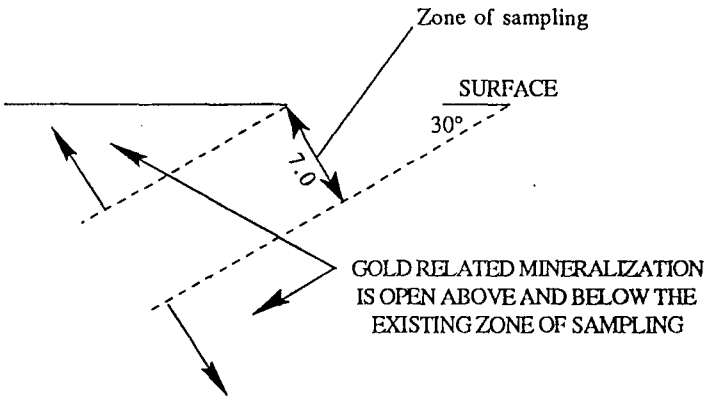
# ALVARADO TRENCH #B+1: CHANNEL SAMPLES ACROSS VEIN SYSTEM: SERIES 143935-143938 & 143929

1"=2 FEET



| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143935 | 1.6 | H.W. | 0.106 |
| 143936 | 1.3 | H.W. | 0.042 |
| 143937 | 2.8 | VEIN | 0.028 |
| 143929 | 2.0 | VEIN | 0.066 |
| 143938 | 1.3 | FW | 0.044 |

N68E:
STRIKE OF VEIN SYSTEM →




**MINIMUM TRUE THICKNESS PERPENDICULAR TO VEIN SYSTEM IS 7 FEET @ 0.055 OPT AU**

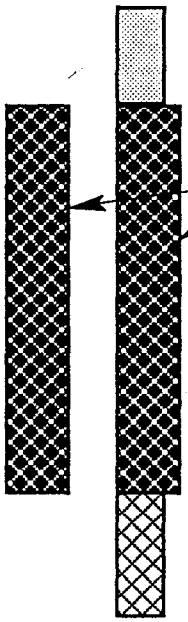
CONQUISTADOR GOLD/MCO

# ALVARADO TRENCH #B+2: CHANNEL SAMPLES ACROSS VEIN SYSTEM: SERIES 143939-143941

1"=2 FEET

NW

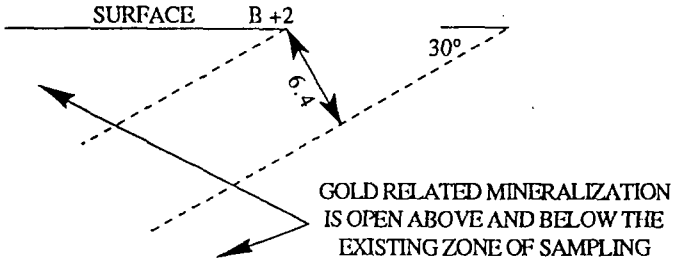
| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143939 | 1 | H.W. | 0.048 |
| 143940 | 4.1 | VEIN | 0.268 |
| 143941 | 1.3 | FW | 0.060 |




**6.4 FT**

N68E:
STRIKE OF VEIN SYSTEM

MINIMUM TRUE THICKNESS PERPENDICULAR TO VEIN IS 6.4 FEET @ **0.191 OPT AU**




*CONQUISTADOR GOLD/MCO*

# ALVARADO TRENCH #B+3: CHANNEL SAMPLES ACROSS VEIN SYSTEM: SERIES 143950-143942

1/2"=1 FOOT

| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143950 | 3.3 | H.W. | 0.026 |
| 143949 | 1.8 | H.W. | 0.023 |
| 143948 | 1.7 | H.W. | 0.046 |
| 143947 | 2.2 | VEIN | 0.451 |
| 143946 | 1.3 | F.W. | 0.036 |
| 143945 | 2 | F.W. | 0.036 |
| 143944 | 1.2 | F.W. | 0.036 |
| 143943 | 1.7 | F.W. | .011 |
| 143942 | 1 | F.W. | 0.010 |

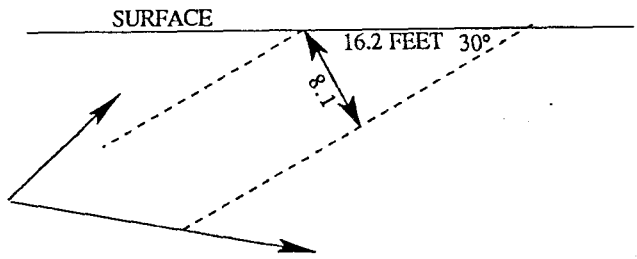
16.2 FEET

GOLD RELATED MINERALIZATION IS OPEN ABOVE AND BELOW THE EXISTING ZONE OF SAMPLING

NW

N68E:
STRIKE OF VEIN SYSTEM

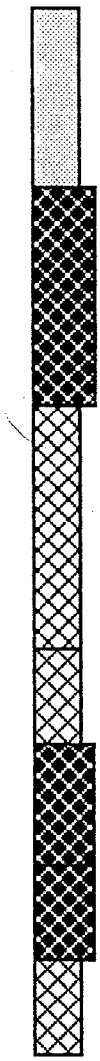
MINIMUM TRUE THICKNESS PERPENDICULAR TO VEIN IS 8.1 FEET @ WEIGHTED AVERAGE OF **0.092 OPT AU**




*CONQUISTADOR GOLD/MCO*

# ALVARADO TRENCH #B+4: CHANNEL SAMPLES ACROSS VEIN SYSTEM: SERIES 143957-143951

1/2"=1 FOOT



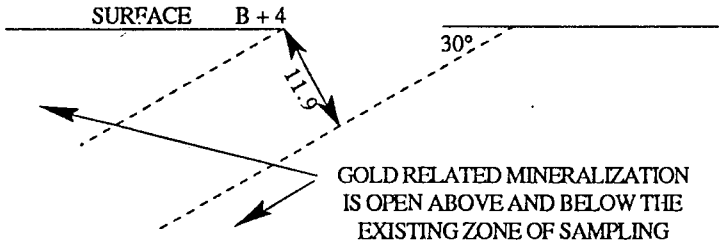
| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143957 | 1.9 | H.W. | 0.029 |
| 143956 | 2.3 | VEIN | 0.022 |
| 143955 | 2.6 | INT. | 0.049 |
| 143954 | 1 | INT. | 0.085 |
| 143953 | 1.7 | VEIN | 0.116 |
| 143952 | 1 | VEIN | 0.184 |
| 143951 | 1.4 | F.W. | 0.039 |

**11.9 FT**

NW

N68E:
STRIKE OF VEIN SYSTEM

THE MINIMUM THICKNESS PERPENDICULAR TO TO THE ZONE OF SAMPLING IS 11.9 FEET @ WEIGHTED AVERAGE OF
**0.063 OPT AU**




CONQUISTADOR GOLD/MCO

# ALVARADO TRENCH #B+5: CHANNEL SAMPLES ACROSS VEIN SYSTEM: SERIES 143971-143958

Vertical: 1/2" = 1 Ft.

NW

B+5

| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143971 | 1 | D.G. | 0.062 |
| 143970 | 1 | QTZ | 0.117 |
| 143969 | 1.7 | OX | 0.113 |
| 143968 | 0.7 | QTZ | 0.070 |
| 143967 | 3.1 | SCHIST | 0.009 |
| 143966 | 1.8 | H.W. | 0.027 |
| 143965 | 1 | VEIN | 0.243 |
| 143964 | 3 | | 0.058 |
| 143963 | 1.4 | OX ~ QTZ | 0.036 |
| 143962 | 1.5 | OX ~ QTZ | 0.403 |

N68E:
STRIKE OF VEIN SYSTEM →

**Weighted Mean for 23 feet = 0.100 OPT Au**

| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143961 | 2.3 | INT. ~ QTZ | 0.101 |
| 143960 | 1.5 | VEIN | 0.203 |
| 143959 | 1.3 | F.W. | 0.036 |
| 143958 | 1.7 | F.W. | 0.021 |

TOTAL LENGTH OF SAMPLE: 23 FT.

B + 5 — SURFACE

23 feet 30°

11.5

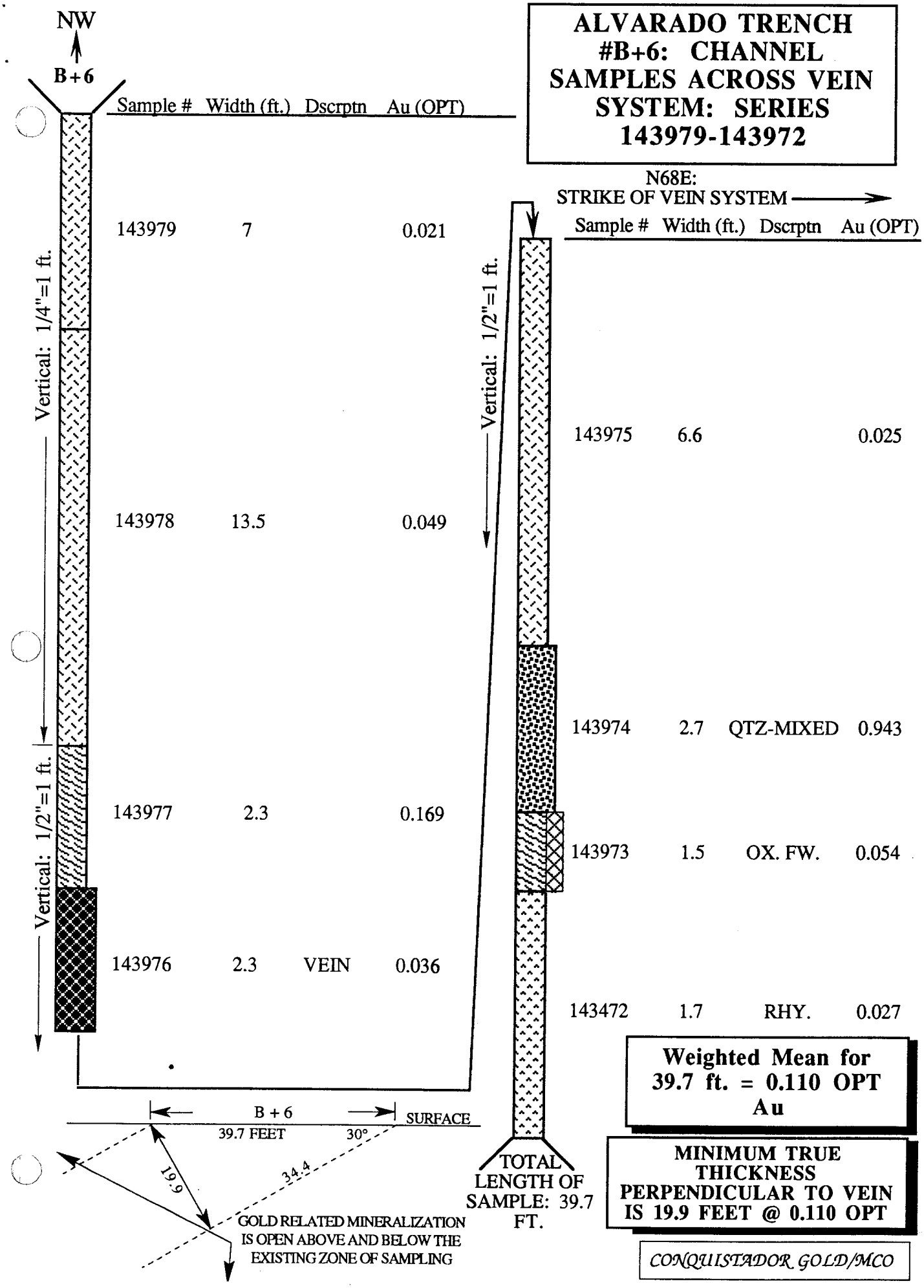
19.9

GOLD RELATED MINERALIZATION IS OPEN ABOVE AND BELOW THE EXISTING ZONE OF SAMPLING

**MINIMUM TRUE THICKNESS PERPENDICULAR TO VEIN IS 11.5 FEET @**

*CONQUISTADOR GOLD/MCO*

# ALVARADO TRENCH #B+6: CHANNEL SAMPLES ACROSS VEIN SYSTEM: SERIES 143979-143972

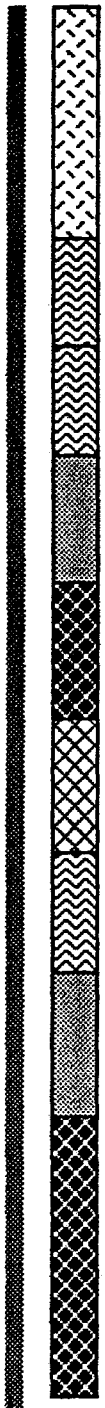



| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143979 | 7 | | 0.021 |
| 143978 | 13.5 | | 0.049 |
| 143977 | 2.3 | | 0.169 |
| 143976 | 2.3 | VEIN | 0.036 |

| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143975 | 6.6 | | 0.025 |
| 143974 | 2.7 | QTZ-MIXED | 0.943 |
| 143973 | 1.5 | OX. FW. | 0.054 |
| 143472 | 1.7 | RHY. | 0.027 |

# ALVARADO TRENCH #B+13: CHANNEL SAMPLES ACROSS VEIN SYSTEM: SERIES 143876-143868

1/2"=1 FOOT



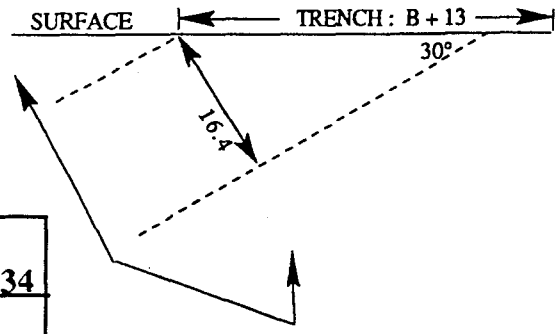
16.4 ft

| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143876 | 2.6 | GR | 0.009 |
| 143875 | 1.2 | SCH | 0.010 |
| 143874 | 1.9 | SCH | 0.012 |
| 143873 | 1.4 | HW | 0.011 |
| 143872 | 1.6 | VEIN | 0.012 |
| 143871 | 1.5 | FW | 0.040 |
| 143870 | 1.3 | SCH | 0.027 |
| 143869 | 1.6 | HW | 0.044 |
| 143868 | 3.1 | VEIN | 1.290 |
| | | SECOND SAMPLE : | 0.587 |

N68E:
STRIKE OF VEIN SYSTEM →

THE MINIMUM THICKNESS PERPENDICULAR TO TO THE ZONE OF SAMPLING IS 16.4 FEET WITH A WEIGHTED AVERAGE OF **0.275 OPT AU** USING A VALUE OF 1.29 OPT AU FOR SAMPLE NO.143868.
OR
A WIDTH OF 10.7 FEET AT **0.417 OPT AU.**

**NATIVE GOLD IS VISIBLE IN SOME AREAS IN THE EXPOSED ROCKS IN THE TRENCH**




GOLD RELATED MINERALIZATION IS OPEN ABOVE AND BELOW THE EXISTING ZONE OF SAMPLING

**WEIGHTED AVERAGE: 0.275 OPT AU** FOR A ZONE 16.4 FEET WIDE USING THE HIGHER VALUE OF 1.29 OPT AU FOR SAMPLE 143868

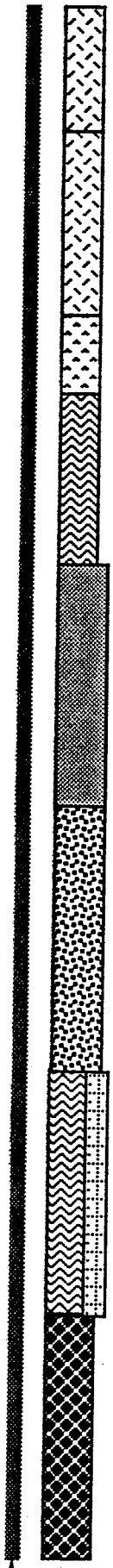
**WEIGHTED AVERAGE: 0.134 OPT AU** FOR A ZONE 16.4 FEET WIDE USING THE LOWER VALUE OF 0.587 OPT AU FOR SAMPLE 143868

A SINGLE CONTINUOUS 27' CHANNEL SAMPLE CUT FROM THE BOTTOM OF THE TRENCH YIELDED A MINIMUM TRUE THICKNESS OF 10.7 FEET WITH **A GRADE OF 0.163 OPT AU**

*CONQUISTADOR GOLD/MCO*

# ALVARADO TRENCH #C+1: CHANNEL SAMPLES ACROSS VEIN SYSTEM: SERIES 143867-143860

1/2"=1 FOOT

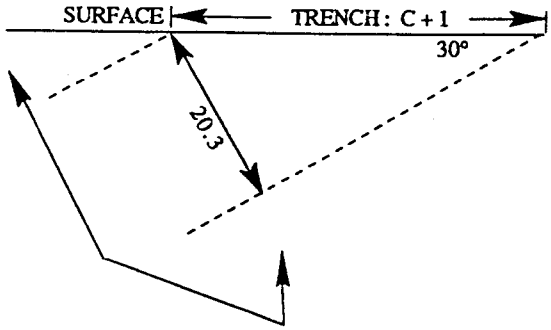


| Sample # | Width (ft.) | Dscrptn | Au (OPT) |
|---|---|---|---|
| 143867 | 1.6 | GR | 0.009 |
| 143866 | 2.4 | GR | 0.021 |
| 143865 | 1 | RHY | 0.040 |
| 143864 | 2.2 | SCH | 0.026 |
| 143863 | 3.1 | OX-HW | 0.024 |
| 143862 | 3.4 | OX-QTZ | 0.119 |
| 143861 | 3.1 | OX-SCH | 0.049 |
| 143860 | 3.5 | VEIN | 0.197 |

N68E:
STRIKE OF VEIN SYSTEM →

THE MINIMUM THICKNESS PERPENDICULAR TO TO THE ZONE OF SAMPLING IS 20.3 FEET @ WEIGHTED AVERAGE OF **0.047 OPT AU**

**NATIVE GOLD IS VISIBLE IN SEVERAL AREAS IN THE EXPOSED ROCKS IN THE TRENCH**




GOLD RELATED MINERALIZATION IS OPEN ABOVE AND BELOW THE EXISTING ZONE OF SAMPLING

A SINGLE CONTINUOUS 35' CHANNEL SAMPLE CUT FROM THE BOTTOM OF THE TRENCH YIELDED A MINIMUM TRUE THICKNESS OF 20.3 FEET WITH **A GRADE OF 0.32 OPT AU**

*CONQUISTADOR GOLD/MCO*

2/11/90

# ALVARADO GOLD MINE
Yavapai county, Arizona

## GOLD VALUES IN DUMPS, ORE PILES, AND TAILINGS ASSAYED IN 1980 BY MOORES

| | SAMPLE DESCRIPTION<br>Flagged with blue tape | GOLD (opt) | SILVER (opt) |
|---|---|---|---|
| D - 1 | Two combined samples of quartz pile, south side of dump in front of east shaft (D-shaft) (Same as AV-6 and AV-13) | 0.088 | 0.04 |
| D - 2 | West cut, north side of C-shaft dump at mill above road material pit | 0.058 | nil |
| D - 3 | East cut north side of C-shaft dump above road material pit | 0.086 | 0.04 |
| D - 4 | South side of same dump as D-3, east cut | 0.126 | tr |
| D - 5 | Second sample from east end of C-shaft dump on south side, 25 ft west of D-4 | 0.110 | tr |
| D - 6 | Third cut from east end of C-shaft dump on south side, 25 ft west of D-5 | 0.076 | tr |
| D - 7 | Fourth sample from east end of C-shaft dump on south side, west end near top | 0.042 | tr |
| D - 8 | First sample from southeast end of B-shaft dump on south side | tr | nil |
| D - 9 | Second sample from southeast end of B-shaft dump on south side | tr | nil |
| D - 10 | Third sample (more quartz-rich) from southeast end of B-shaft dump on south side | 0.048 | nil |
| D - 11 | Small dump in front of A-shaft. Sample is mostly rhyolite | tr | tr |
| D - 13 | Sulfide ore from piles west of main shaft (C-shaft) | 0.25 | 0.51 |
| | Second sample from D-13 (oxidized) | 0.25 | - |
| D - 14 | Dump at shaft on cross vein on new location claim east of Alvarado | 0.10 | 0.68 |
| D - 12 | TAILINGS FROM LAST OPERATION: "not conclusive" | 0.035 | tr |
| | TAILINGS FROM FORMER OPERATION NEAR CAMP | 0.05 | tr |

<u>ESTIMATED TONNAGES</u>: DUMPS: 40,000 TO 50,000 (quartz-rich, "waste" dumps have not been sampled)
TAILINGS, last operation: 100,000
TAILINGS, former operation: 5,000

## GOLD VALUES IN SELECTED DUMP SAMPLES AFTER SCREENING TO MINUS 2 INCH

| SAMPLE | ORIGINAL VALUE | AFTER SCREENING | %INCREASE |
|---|---|---|---|
| D-2 | 0.058 | 0.08 | 38% |
| D-3 | 0.076 | 0.12 | 58% |
| D-4 | 0.126 | 0.18 | 50% |
| D-5 | 0.110 | 0.14 | 27% |

*Raul J. Madrid* *Ralph J. Roberts*

*Co-CEO's*

JDS → file

WKK

**ASARCO**

Southwestern Exploration Division

other people, once again make project look more interesting than Asarco's personnel do. Enough time at reasonable cost possible?

April 27, 1990

J.D. Sell

Alvarado Mine
Conquistador Gold
Yavapai County, AZ

MAM has not drawn any sections to suggest true thickness of zone nor waste configuration. Thoughts from map suggests a problem at Alvarado, but? along strike in flats ?? JDS

During the meeting in Reno, I met with Raul Madrid who along with Ralph Roberts is co-president of Conquistador Gold. They currently have control of the Alvarado Mine property which is southwest of the Yarnell Mine area. Conquistador Gold has recently completed some trenching on the property which looks interesting (attached). According to their data, they show additional mineralization which is found in the hanging wall and footwall of the vein structures. They have also identified additional veins parallel to the main Alvarado vein. Their sampling suggests that there is additional mineralization as most of their trenches end in mineralized rock.

Madrid also said that the Alvarado and the Yarnell structure are the same: only offset by a cross fault. I don't think that this is right, as the Yarnell Fault can be traced from the mine area fairly continuously to the southwest past the overlook. (This would put the Alvarado structure in the footwall of the Yarnell Fault.)

Anyway, the mineralization that they are finding is interesting and I recommend that we do additional sampling to see if the zone can be widened. Several logistical problems may exist. The ore zone is dipping to the NW which will project under the Yarnell grade highway and the stripping will increase considerably to the NW. The zone may be open to the SW under the pediment cover.

This was suggested in memo to MAM by WLK + JDS on May 10, 1989

also this is on MAM list of Study for Greater Yarnell JDS.

MAM:mek

Mark A. Miller

CC: W.L. Kurtz

copy for S L Lahosky
& me

FILE
JDS

Don White
521 E. Willis St.
Prescott, AZ 86301
602-778-3140

April 27, 1990

James D. Sell
Manager, S.W. Exploration
ASARCO, INC.
PO Box 5747
Tucson, AZ 85703

Dear Jim,

I have followed the news of Norgold's work and now your efforts at the Yarnell property with interest.

What are the chances of your wanting geological help on future work there? I submit that my proximity to Yarnell and ability to give it time as needed, without coming and going to Tucson or having other lodging and food expenses, would be cost effective for your program. My fee is $240./day.

I believe you are familiar with the quality of my work at the U.V.X. and Vulture mines. I've been managing major drilling programs with multiple rigs in Nevada and Costa Rica the past year. I return to Costa Rica for May 2-31st but shall be available again, starting in June.

I look forward to learning the status of the Yarnell project. Let me know if it will be possible to contribute to that program.

Sincerely,

Don

Don White
Geologist, C.P.G.

ASARCO Incorporated

APR 30 1990

SW Exploration

GEOCHEMICAL SERVICES INC.

# GEOCHEMICAL ANALYSIS REPORT

ASARCO Incorporated
MAY 4 1990
SW Exploration

TO: J.D. Rasmussen
ASARCO Inc.
P. O. Box 5747
Tucson, AZ 85703 tel:602/792-3010

==========

Job Number: ASB-OR1810
Analysis Code: SRP15
Digest: 15 gram
Total number of samples: 48

==========

This report has been reviewed and approved by:

Nancy G. Gonzalez for Date: 5/2/90
Mary Leitch, Quality Assurance Manager

3805 Atherton Road • Rocklin, California 95677 • 916/624-6000 1/800/827-4GSI FAX: 916/624-8986
1498 Kleppe Lane • Sparks, Nevada 89431 • 702/359-6600 FAX: 702/359-6605

JDS

GEOCHEMICAL SERVICES INC.

# GEOCHEMICAL ANALYSIS REPORT

JOB #: ASB-OR1810



| SAMPLE ID | # | Ag ppb | Au ppb | As ppm | Bi ppm | Cd ppm | Hg ppm | Sb ppm | Se ppm | Te ppm | Cu ppm | Mo ppm | Pb ppm | Zn ppm | Ga ppm | Tl ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YA 350 | 1 | 88.1 | .805 | 4.10 | .313 | .126 | <.02 | .480 | <.247 | <.049 | 12.8 | 1.06 | 26.0 | 51.0 | 4.56 | <.495 |
| YA 352 | 2 | 44.0 | 2.57 | 6.21 | .416 | .162 | <.02 | .546 | .403 | <.049 | 17.7 | 1.30 | 35.8 | 63.9 | 4.83 | <.493 |
| YA 354 | 3 | 33.9 | 2.85 | 4.99 | .404 | .171 | <.02 | .414 | .406 | <.049 | 16.2 | 1.62 | 29.6 | 66.7 | 5.35 | <.49 |
| YA 356 | 4 | 42.4 | 5.92 | 3.65 | .361 | .128 | <.02 | .301 | <.246 | .067 | 15.1 | 1.06 | 18.1 | 51.7 | 4.37 | <.492 |
| YA 358 | 5 | 49.7 | 3.03 | 6.88 | .513 | .240 | <.02 | .612 | <.245 | .151 | 19.7 | 2.05 | 28.8 | 79.6 | 6.56 | .680 |
| YA 360 | 6 | 30.6 | 10.7 | 4.67 | .330 | .155 | <.02 | .317 | <.246 | .072 | 14.6 | 1.44 | 21.7 | 67.7 | 4.69 | <.493 |
| YA 362 | 7 | 52.5 | 2.94 | 7.67 | .391 | .123 | <.02 | .474 | .398 | .089 | 16.7 | 1.28 | 27.1 | 72.2 | 5.39 | .517 |
| YA 364 | 8 | 62.3 | 3.51 | 4.65 | .604 | .235 | <.02 | .437 | <.245 | .06 | 21.9 | 1.55 | 31.3 | 82.8 | 5.94 | .573 |
| YA 366 | 9 | 18.0 | 2.12 | 3.80 | .342 | .103 | <.019 | .374 | <.244 | <.049 | 11.9 | .960 | 19.1 | 59.0 | 4.87 | .544 |
| YA 368 | 10 | 32.7 | 1.32 | 4.48 | .358 | .202 | <.02 | .400 | .318 | <.049 | 15.8 | 1.02 | 23.6 | 66.6 | 4.87 | .526 |
| YA 370 | 11 | 49.1 | 8.51 | 6.89 | .432 | .164 | <.019 | .507 | <.242 | <.048 | 18.7 | .973 | 30.0 | 86.5 | 6.65 | .502 |
| YA 372 | 12 | 35.2 | 2.88 | 3.64 | .318 | .125 | <.02 | .304 | <.244 | .08 | 16.4 | .850 | 17.1 | 67.2 | 4.58 | <.489 |
| YA 374 | 13 | 59.5 | 6.54 | 4.53 | .362 | .149 | <.02 | .437 | <.248 | <.05 | 18.0 | 1.14 | 26.6 | 71.8 | 5.21 | <.497 |
| YA 376 | 14 | 32.2 | 2.37 | 4.72 | .371 | .120 | <.02 | .541 | <.248 | .096 | 16.8 | 1.32 | 20.7 | 63.0 | 5.33 | <.496 |
| YA 378 | 15 | 30.7 | 1.23 | 3.85 | .385 | .151 | <.019 | .356 | <.244 | .051 | 14.6 | .823 | 16.0 | 63.6 | 4.28 | .487 |
| YA 380 | 16 | 32.3 | 6.68 | 3.34 | .341 | .146 | <.02 | .367 | <.245 | <.049 | 16.6 | .865 | 15.0 | 76.8 | 4.93 | <.491 |
| YA 382 | 17 | 45.1 | 9.98 | 5.52 | .513 | .215 | <.02 | .479 | <.245 | <.049 | 17.4 | .959 | 26.0 | 73.4 | 5.37 | .615 |
| YA 384 | 18 | 38.4 | .263 | 4.42 | .422 | .155 | <.019 | .465 | .324 | .056 | 17.1 | 1.01 | 18.4 | 64.9 | 4.58 | <.487 |
| YA 386 | 19 | 40.5 | 93.2 | 3.61 | .380 | .164 | <.02 | .346 | <.245 | <.049 | 16.4 | .791 | 17.0 | 62.6 | 4.26 | <.49 |
| YA 388 | 20 | 47.8 | .821 | 2.89 | .326 | .172 | <.019 | .274 | .256 | <.049 | 18.4 | .830 | 16.8 | 64.2 | 4.10 | <.487 |
| YA 390 | 21 | 54.8 | 3.84 | 4.72 | .490 | .220 | <.02 | .435 | .544 | .104 | 18.5 | 1.17 | 24.6 | 71.0 | 4.82 | .648 |
| YA 392 | 22 | 35.4 | 17.2 | 3.25 | .293 | .157 | <.02 | .359 | <.247 | <.049 | 14.1 | .682 | 12.4 | 56.4 | 3.27 | <.493 |
| YA 394 | 23 | 38.5 | 16.6 | 2.96 | .302 | .114 | <.02 | .277 | <.248 | <.05 | 15.8 | .787 | 12.6 | 56.2 | 3.89 | <.497 |
| YA 396 | 24 | 36.4 | 2.76 | 5.06 | .347 | .106 | <.02 | .412 | <.25 | .081 | 14.5 | 1.55 | 24.3 | 62.4 | 4.73 | <.499 |
| YA 398 | 25 | 35.5 | 1.48 | 3.78 | .337 | .214 | <.02 | .441 | <.248 | <.05 | 13.0 | .998 | 17.0 | 55.9 | 3.18 | <.495 |
| YA 400 | 26 | 23.8 | 1.04 | 4.02 | .286 | .131 | <.02 | .424 | .286 | <.049 | 10.9 | 1.20 | 17.1 | 50.4 | 3.29 | <.49 |
| YA 402 | 27 | 33.6 | 1.52 | 3.31 | .233 | .127 | <.02 | .239 | <.246 | <.049 | 12.5 | .678 | 10.9 | 41.1 | 2.71 | <.491 |
| YA 404 | 28 | 47.7 | 20.5 | 4.26 | .263 | .118 | <.02 | .387 | <.245 | <.049 | 11.7 | 1.21 | 15.5 | 47.2 | 4.50 | <.49 |
| YA 406 | 29 | 42.9 | .429 | 6.28 | .428 | .131 | <.019 | .740 | <.244 | <.049 | 13.9 | 1.30 | 20.5 | 45.9 | 4.20 | <.487 |
| YA 408 | 30 | 41.1 | 4.30 | 5.44 | .394 | .183 | <.02 | .520 | <.245 | .116 | 13.6 | 1.45 | 21.0 | 53.5 | 3.31 | <.489 |

3805 Atherton Road • Rocklin, California 95677 • 916/624-6000 1/800/827-4GSI FAX: 916/624-8986
1498 Kleppe Lane • Sparks, Nevada 89431 • 702/359-6600 FAX: 702/359-6605

GEOCHEMICAL SERVICES INC.

# GEOCHEMICAL ANALYSIS REPORT

JOB #: ASB-OR1810



| SAMPLE ID | # | Ag ppb | Au ppb | As ppm | Bi ppm | Cd ppm | Hg ppm | Sb ppm | Se ppm | Te ppm | Cu ppm | Mo ppm | Pb ppm | Zn ppm | Ga ppm | Tl ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YA 410 | 31 | 46.0 | 1.70 | 4.67 | .289 | .124 | <.02 | .430 | <.247 | <.049 | 16.8 | .959 | 19.0 | 55.9 | 4.08 | <.494 |
| YA 412 | 32 | 51.3 | .684 | 4.28 | .306 | .115 | <.02 | .331 | <.245 | .05 | 16.3 | .973 | 15.8 | 50.2 | 4.23 | <.489 |
| YA 414 | 33 | 44.4 | 16.0 | 3.86 | .215 | .105 | <.019 | .301 | .311 | <.049 | 13.0 | .718 | 13.2 | 37.0 | 3.02 | <.487 |
| YA 416 | 34 | 36.1 | 4.08 | 4.37 | .253 | .079 | <.02 | .319 | .246 | <.049 | 12.5 | 1.02 | 15.4 | 41.6 | 3.41 | <.489 |
| YA 418 | 35 | 48.2 | 2.05 | 5.30 | .385 | .163 | <.02 | .498 | .288 | .077 | 17.2 | 1.32 | 22.2 | 56.2 | 4.43 | .516 |
| YA 420 | 36 | 41.3 | 2.61 | 8.03 | .480 | .173 | <.02 | .649 | .354 | <.05 | 13.8 | 2.09 | 30.3 | 58.6 | 4.63 | .499 |
| YA 422 | 37 | 30.7 | .489 | 4.78 | .292 | .100 | <.02 | .448 | <.244 | .06 | 13.6 | 1.30 | 17.2 | 53.6 | 4.22 | <.488 |
| YA 424 | 38 | 28.1 | 1.27 | 4.05 | .309 | .087 | <.019 | .328 | <.243 | <.049 | 10.4 | .983 | 14.6 | 40.2 | 3.85 | <.486 |
| YA 426 | 39 | 42.3 | .239 | 2.79 | .216 | .111 | <.02 | .234 | <.246 | .067 | 13.0 | .564 | 10.6 | 36.8 | 2.80 | <.492 |
| YA 428 | 40 | 30.4 | .643 | 4.14 | .372 | .112 | <.02 | .374 | <.246 | .102 | 11.8 | 1.14 | 14.0 | 39.6 | 3.30 | <.491 |
| YA 430 | 41 | 48.4 | 3.95 | 5.77 | .387 | .202 | <.02 | .530 | <.245 | <.049 | 15.6 | 1.72 | 22.2 | 60.1 | 4.18 | <.49 |
| YA 432 | 42 | 40.0 | 1.78 | 6.25 | .370 | .106 | <.019 | .617 | <.243 | <.049 | 15.9 | 1.36 | 17.7 | 67.1 | 4.97 | <.486 |
| YA 434 | 43 | 32.9 | 1.14 | 3.34 | .282 | .135 | <.019 | .338 | <.244 | .06 | 12.8 | .775 | 12.9 | 46.3 | 3.47 | <.487 |
| YA 436 | 44 | 38.8 | .708 | 3.96 | .274 | .107 | <.02 | .344 | <.248 | <.05 | 14.4 | .880 | 13.3 | 50.2 | 4.23 | <.495 |
| YA 438 | 45 | 40.9 | 1.28 | 7.08 | .692 | .092 | <.02 | .435 | .299 | .053 | 15.5 | 1.58 | 22.7 | 49.7 | 4.44 | <.49 |
| YA 440 | 46 | 42.7 | .483 | 4.98 | .298 | .116 | <.02 | .431 | <.248 | <.05 | 15.7 | 1.33 | 18.0 | 54.0 | 4.62 | <.497 |
| YA 442 | 47 | 34.1 | 1.79 | 4.24 | .356 | .109 | <.02 | .357 | <.244 | <.049 | 14.9 | .836 | 13.7 | 50.2 | 3.96 | <.489 |
| YA 444 | 48 | 30.2 | 2.70 | 5.40 | .406 | .176 | <.02 | .446 | .335 | .149 | 17.2 | 1.51 | 22.2 | 56.5 | 4.94 | <.494 |

3805 Atherton Road • Rocklin, California 95677 • 916/624-6000 1/800/827-4GSI FAX: 916/624-8986
1498 Kleppe Lane • Sparks, Nevada 89431 • 702/359-6600 FAX: 702/359-6605

CC: S.A. Anzalone
S.L. Lakosky
M.A. Miller
T.E. Scartaccini
J.D. Sell
(5/8/90)

# RGOLD RESOURCES INC.

# EWS RELEASE

MBOL: NGR EXCHANGE: V.S.E.

MAY 2, 19 90

**FOR IMMEDIATE RELEASE**

Mr. Michael D. Philpot, President, is very pleased to announce that Messrs. Steven C. Potter, Richard W. Graeme and Robert W. Schafer have joined the Norgold Resources "U.S." Inc. team in the capacity of President, Vice-President Operations and Vice-President Exploration and Acquisition, respectively.

Mr. Potter, B.S. in Geological Engineering and M.S. in Geology, brings to the Company 25 years of diversified experience in the minerals business with Homestake Mining Co., Ranchers Exploration and Development Corp., Kennecott Minerals Co. and First Sierra Gold Corporation and has participated in the exploration and/or development of six precious metal deposits which are presently in production or at an advanced stage of exploration.

Mr. Graeme, B.S. in Geological Engineering, brings with him 29 years of experience with Phelps Dodge, Sharon Steel and Gold Fields. Mr. Graeme has managed four gold mines since 1984: Ortiz, New Mexico; Mesquite, California; Alaska Gold (placer), Alaska; and Ruby Hill, Nevada.

Mr. Schafer, B.S. and M.S. in Geology and M.S. in Mineral Economics, has over 13 years of experience in exploration and business development, including management positions with Addwest Gold and Billiton International Metals and project experience with U.S. Borax and Chemical Company and MAPCO. More than 1.5 million ounces of gold were discovered by Addwest while Mr. Schafer was their Exploration Manager.

Messrs. Potter, Graeme and Schafer's combined experience in the mining industry provides Norgold with the necessary entrepreneurial, management and technical skills that are rarely experienced at the junior mining company level. It will be the team's mandate to acquire significant gold projects having the potential for reserve expansion. This will add to the company's gold reserve base and serve as a springboard to enhancing the company's status as a future gold producer.

We at Norgold Resources Inc. would like to take this opportunity to welcome Messrs. Potter, Graeme and Schafer on board and look forward to a very exciting and successful future.

On Behalf of the Board,

Michael D. Philpot
C.E.O. & President

RECEIVED
MAY 8 1990
EXPLORATION DEPARTMENT

The Vancouver Stock Exchange has neither approved nor disapproved the contents of this release.

**FOR MORE INFORMATION CONTACT CORPORATE RELATIONS**
*Head Office: 210 - 475 Howe Street, Vancouver, British Columbia V6C 2B3*
*Telephone: (604) 681-5566 Fax: (604) 687-8789*

**ASARCO**

**Southwestern Exploration Division**

May 2, 1990

W.D. Gay

Pennsylvania Unpatented
Claim Drill Holes with
Intercepts
Yarnell Project
Yavapai County, AZ

Per your request I have tabulated the drill holes with intercepts which lie within the Pennsylvania Unpatented Lode Claim.

| Hole No. YM- | Intercept (opt Au) |
|---|---|
| 10 | 190-225 (35') @ .029 |
| 11 | 175-240 (65') @ .049 |
| 22 | 270-285 (15') @ .025 |
| 23 | 40-125 (85') @ .047 |
| 29 | 220-230 (10') @ .033 |
| 46 | 200-260 (60') @ .012 |
| 47 | 170-205 (35') @ .031 |
| 49 | 140-160 (40') @ .049 |
| 51 | 165-170 (5') @ .061 |
| 75 | 105-160 (65') @ .066 |

MAM:mek

Mark A. Miller
Project Geologist

cc: J.D. Sell

JDS

**ASARCO**

**Southwestern Exploration Division**

May 2, 1990

J.D. Sell

Carl Olsen Property
Yarnell Project
Yavapai County, AZ

As you are aware, Carl Olsen was killed on 4/29/90 in a vehicle accident. Carl was the owner of two lode claims and one mill site adjoining our eastern claim boundary (Gold Rock 1 & 2, mill site).

The attached decision on Inheritance of Mining Claims upon the death of the owner (from Handbook of Mineral Law 3rd Edition, T.S. Maley) states that the claims will pass to his heirs. If we are still interested we should find out the disposition of the claims, and we may be able to purchase them for less than the $15,000 Olsen wanted.

MAM:mek

Mark A. Miller
Project Geologist

cc: S.L. Lakosky
W.D. Gay
W.L. Kurtz

## Community Property

The posesssory right to a mining claim is not community property. *Phoenix Mining Co. v. Scott,* 54 P 777 (1898).

## Quiet Title and Trespass Actions

Quiet title actions and trespass actions apply to mining claims as they do to real estate. *Black v. Elkhorn Mining Co.,* 49 F 549, 552 (1892), *affirmed,* 163 US 445. Furthermore, a mining claim comes under the statute of limitations. *Lavagnino v. Uhlig,* 71 P 1046 (1903), *affirmed,* 198 US 443.

## Transfer of Mining Claims

Mining claims may be transferred by deed. *Roseville Alta Mining Co. v. Iowa Gulch Mining Co.,* 24 P 920 (1890). And a locator may convey any portion of a mining claim. *St. Louis Mining Co. v. Montana Mining Co.,* 171 US 650 (1898).

## Surface Rights

The Multiple Surface Act of July 23, 1955 was enacted to provide a means for the Federal Government to obtain management rights of surface resources on mining claims located both before and after the Act. As a result any use of the surface of an unpatented claim for purposes unrelated to mining is unauthorized and subject to trespass action by the surface management agency.

## Grazing Rights

Grazing rights are not included in the posesssory rights of a mining claim. *United States v. Etcheverry,* 230 F2d 193 (1956).

## Inheritance of Mining Claims

Upon the death of the owner of a mining claim, the identical rights and interests of the claimant passes to his heirs by descent. These interests may be sold as other property by an executor or administrator. *O'Connell v. Pinnacle Gold Mines Co.,* 140 F 854 (1905).

## Mining Claims are Subject to Liens

Unpatented mining claims are real property, and as such, are subject to liens. *Bradford v. Morrison,* 212 US 389 (1909).

## Termination of Rights

The possessory rights of a mining claim may be terminated by abandonment or loss of discovery. See other sections of this book for detailed discussions of abandonment and discovery.

5/3/90

JDS-ell

Please call Mike Philpot concerning a tour of Yarnell for his new U.S. crew (Steve Potter, Bob Shaefer and Dick Gream — all good men). He is having them see the US Staff May 14-16 (15-16) 14-18

KURTZ

5-3-90
Set up for Monday 14th at Yarnell

cc: W.L. Kurtz
J.D. Sell
M.A. Miller
S.L. Lakosky

# FACSIMILE TRANSMISSION

DATE: May 2, 1990

TO: ASARCO, Inc

ATTENTION:

TOTAL NO. OF PAGES: 2 (including this page)

FROM: H. Philpot.

Suite 206/210 - 475 Howe Street
Vancouver, B.C.
V6C 2B3 Canada

Telephone: (604) 681-5566

Facsimile No.: (604) 687-8789

RECEIVED
MAY 2 1990
EXPLORATION DEPARTMENT

* * * * * * * * * * * * * * * *

IF THIS TRANSMISSION IS NOT FULLY OR LEGIBLY RECEIVED

PLEASE TELEPHONE (604) 687-4144

OPERATOR:

NOTES:

# NORGOLD RESOURCES INC.

TRADING SYMBOL: NGR
STOCK EXCHANGE: VSE

MAY 01, 1990
#90-05

NEWS RELEASE

---

Mr. Michael D. Philpot, President, is very pleased to announce that Messrs. Steven C. Potter, Richard W. Graeme and Robert W. Schafer have joined the Norgold Resources "U.S." Inc. team in the capacity of President, Vice-President Operations and Vice-President Exploration and Acquisition, respectively.

Mr. Potter, B.S. in Geological Engineering and M.S. in Geology, brings to the Company 25 years of diversified experience in the minerals business with Homestake Mining Co., Ranchers Exploration and Development Corp., Kennecott Minerals Co. and First Sierra Gold Corporation and has participated in the exploration and/or development of six precious metal deposits which are presently in production or at an advanced stage of exploration.

Mr. Graeme, B.S. in Geological Engineering, brings with him 29 years of experience with Phelps Dodge, Sharon Steel and Gold Fields. Mr. Graeme has managed four gold mines since 1984: Ortiz, New Mexico; Mesquite, California; Alaska Gold (placer), Alaska; and Ruby Hill, Nevada.

Mr. Schafer, B.S. and M.S. in Geology and M.S. in Mineral Economics, has over 13 years of experience in exploration and business development, including management positions with Addwest Gold and Billiton International Metals and project experience with U.S. Borax and Chemical Company and MAPCO. More than 1.5 million ounces of gold were discovered by Addwest while Mr. Schafer was their Exploration Manager.

Messrs. Potter, Graeme and Schafer's combined experience in the mining industry provides Norgold with the necessary entrepreneurial, management and technical skills that are rarely experienced at the junior mining company level. It will be the team's mandate to acquire significant gold projects having the potential for reserve expansion. This will add to the company's gold reserve base and serve as a springboard to enhancing the company's status as a future gold producer.

We at Norgold Resources Inc. would like to take this opportunity to welcome Messrs. Potter, Graeme and Schafer on board and look forward to a very exciting and successful future.

On Behalf of the Board,

Michael D. Philpot
C.E.O. & President

The Vancouver Stock Exchange has neither approved nor disapproved the contents of this release.

JDS

**ASARCO**

**Southwestern Exploration Division**

May 3, 1990

S.L. Lakosky

Carl Olsen Property
Yarnell Project
Yavapai County, AZ

Mr. M.A. Miller has sent by the note on Mr. Carl Olsen's (deceased) claims just south of the proposed leach recovery ponds at Yarnell.

Carl often waited till the last days to do his assessment and it may be that he had not yet performed for the year ending August 31, 1990.

As several other people in the Yarnell area are very good at re-staking on September 1, it may be that if you are interested in the claims, then you should follow up as to who the executor or administrator might be for the C. Olsen estate.

James D. Sell

JDS:mek

James D. Sell

cc: W.L. Kurtz
W.D. Gay
M.A. Miller

JDS

**ASARCO**

**Southwestern Exploration Division**

May 10, 1990

W.L. Kurtz

J.J. Malusa's report
Yarnell Project
Yavapai County, AZ

J.J. Malusa's report (May 9, 1990) listed the B Zone core intervals from core holes YDDH-1, YDDH-2, and YDDH-4. (YDDH-3 entered a stope and did not recover all of the B Zone and was not used for this study.)

The sample sent to Jack MacPartland (McClelland Labs) was from the 3/8" crushed reject of the half core sawn from the intervals in the core holes which had been sent for assay.

The remaining half of core is stored for further study.

James D. Sell

JDS:mek

James D. Sell

cc: D.E. Crowell
M.A. Miller
J.J. Malusa

JDS

**ASARCO**

**Southwestern Exploration Division**

May 9, 1990

J.D. Sell

Yarnell Project
Yavapai County, AZ

On May 7 and 8, 1990, I was in Yarnell, Arizona, to accomplish three objectives.

1. Obtained a 55 gallon barrel of fault gouge from an exposure within the open cut. Upon visual estimation the gouge contained approximately 33% clays, 33% pulverized country rock, 33% silica.

2. Located and weighed the B zone core intervals from holes YDDH-1, YDDH-2, YDDH-4. Details are contained within Attachment A.

3. Went into underground working in order to collect a clay sample to be used for K-AR dating of illite clay.

Both the 55 gallon barrel of gouge and the B zone core intervals were sent to:

Jack MacPartland
1016 Greg St.
Sparks, NV
(702) 356-1300

by way of: Pleuger Trucking of Wickenburg, Arizona, 684-2808, for the verbally agreed price of $550.

John J. Malusa

JJM:mek
Atts.

cc: D.E. Crowell
M.A. Miller
W.L. Kurtz

Yarnell Project

Yavapai County, AZ

YDDH-1 B Zone (225-275)

| Interval (ft.) | Weight | opt Au |
|---|---|---|
| 225 - 230 | 7.5 lbs. | .043 |
| 230 - 235 | 8.2 lbs. | .013 |
| 235 - 240 | 7.3 lbs. | .003 |
| 240 - 245 | 8.2 lbs. | .016 |
| 245 - 250 | 6.2 lbs. | .009 |
| 250 - 255 | 8.2 lbs. | .065 |
| 255 - 260 | 6.5 lbs. | .079 |
| 260 - 265 | 6.4 lbs. | .153 |
| 265 - 270 | 6.5 lbs. | .012 |
| 270 - 275 | 10.0 lbs. | .019 |

Yarnell Project

Yavapai County, AZ

YDDH-2 B Zone (275-380)

| Interval (ft.) | Weight | opt Au |
|---|---|---|
| 275 - 280 | 6.7 lbs. | .015 |
| 280 - 285 | 10.0 lbs. | .011 |
| 285 - 290 | 9.5 lbs. | .011 |
| 290 - 295 | 9.3 lbs. | .067 |
| 295 - 300 | 7.0 lbs. | .031 |
| 300 - 305 | 8.6 lbs. | .122 |
| 305 - 310 | 7.6 lbs. | .077 |
| 310 - 315 | 9.2 lbs. | .320 |
| 315 - 320 | 10.1 lbs. | .091 |
| 320 - 325 | 6.4 lbs. | .015 |
| 325 - 330 | 6.7 lbs. | .079 |
| 330 - 335 | 7.4 lbs. | .174 |
| 335 - 340 | 9.6 lbs. | .099 |
| 340 - 345 | 11.6 lbs. | .029 |
| 345 - 350 | 10.7 lbs. | .029 |
| 350 - 355 | 7.9 lbs. | .082 |
| 355 - 360 | 4.7 lbs. | .152 |
| 360 - 365 | 8.4 lbs. | .036 |
| 365 - 370 | 9.7 lbs. | .013 |
| 370 - 375 | 9.5 lbs. | .046 |
| 375 - 380 | 7.6 lbs. | .008 |

Yarnell Project

Yavapai County, AZ

YDDH-4 B Zone (105-170)

| Interval (ft.) | Weight | opt Au |
|---|---|---|
| 105 - 110 | 9.6 lbs. | .095 |
| 110 - 115 | 8.7 lbs. | .076 |
| 115 - 120 | 8.4 lbs. | .067 |
| 120 - 125 | 10.6 lbs. | .021 |
| 125 - 130 | 9.1 lbs. | .190 |
| 130 - 135 | 8.4 lbs. | .021 |
| 135 - 140 | 7.6 lbs. | .024 |
| 140 - 145 | 9.6 lbs. | .022 |
| 145 - 150 | 6.9 lbs. | .045 |
| 150 - 155 | 8.1 lbs. | .155 |
| 155 - 160 | 9.4 lbs. | .125 |
| 160 - 165 | 7.6 lbs. | .020 |
| 165 - 170 | 7.7 lbs. | .018 |

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

yarnell

REPORT OF ANALYSIS

JOB NO. TAJ 635
May 10, 1990
Y 301-305
PAGE 1 OF 1

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

Analysis of 5 Rock Chip Samples

| ITEM | SAMPLE NO. | FIRE ASSAY Au* (ppm) | Ag (ppm) | As (ppm) | Sb (ppm) | Hg (ppm) |
|---|---|---|---|---|---|---|
| 1 | Y-301 | .004 | .35 | 4.6 | 1.4 | .02 |
| 2 | Y-302 | .020 | .20 | 3.8 | .3 | .01 |
| 3 | Y-303 | <.002 | .20 | 2.6 | .2 | .01 |
| 4 | Y-304 | <.002 | .20 | 5.5 | 1.1 | .01 |
| 5 | Y-305 | <.002 | .15 | 4.8 | .9 | .01 |

*NOTE: Method of analysis by combination fire assay and atomic absorption.

cc: Mr. James Rasmussen
Mr. Mark Miller

ASARCO Incorp.
MAY 14 1990
SW Exploration

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

?

5/11/90

MEMO TO J.D. SCHL.

DRILLING ADDITIVES
CONE DRILLING
GARNER PROJECT

~~AS MENTIONED~~, WE HAVE USED THE FOLLOWING ADDITIVES IN OUR TARNGL CONE DRILLING

(1) ALCOMER 120 L-OS. - HOLE CONDITIONER
+/- 35% POLYMER
±4% SURFACTANTS (ACTIVATOR)
+/- 50% LOW TOXIC, LOW AROMATIC CONTENT PALE MINERAL OIL (CARRIER)

THE POLYMER HAS A LOW FLASH POINT ± 2-300°
∴ IT WOULD BE GONE QUICKLY IN A FIRE ASSAY.

THE POLYMER IS STABLE AND WILL STAY AROUND FOR A WHILE UNLESS BROKEN DOWN BY OXIDIZING AGENTS.

(2) MUD-2 BENTONITE

(3) FLUID PLUG. VEGOLABO OIL - LOSS OF CIRCULATION, STUCK RODS -

(4) MINEX GREASE (ROD LUBE) FOR DRY HOLES

67% PALE MINERAL OIL

18% TALLOW

11% $Ba(OH)_2$

4% ACETIC ACID

1% $H_2O$

5 THREAD DOPE (FOR PIPE THREADS) BAKER LUBE Z-50

MIN 50% METALLIC ZINC

Ca .05% CALCIUM

ALL OF THESE ADDITIVES ARE ROUTINELY USED IN GOLD EXPLORATION. THEY SHOULD NOT INTERFERE W/ THE ASSAYING.

JDS

**ASARCO**

**Southwestern Exploration Division**

May 24, 1990

W.L. Kurtz

M.A. Miller's Report
"B" Zone Assay Comparison
RDH vs. DDH Holes
Yarnell Project
Yavapai County, Arizona

Mr. Miller's report on the comparison of assays between the rotary hole and the twinned diamond drill hole assays is attached.

As Miller notes, the individual assays may vary considerably, especially in the higher grades, whereas the totals of the individual holes, in the "B" zone, vary no more than 0.01 opt gold.

I further look at the values, and for the average of the entire hole, the rotary hole is lower than the core hole by about twice as much, as shown in Table 1.

Table 1. Comparison of average net difference of rotary value being higher or lower than core hole value.

| Hole No. | Average, opt Au: No. of Samples | Rotary Higher | No. of Samples | Rotary Lower |
|---|---|---|---|---|
| YDDH-1 | 8 | +0.013 | 2 | -0.054 |
| YDDH-2 | 10 | +0.025 | 11 | -0.042 |
| YDDH-4 | 9 | +0.033 | 12 | -0.040 |
| Weighted Average | 27 | +0.024 | 25 | -0.042 |

In looking at the higher values, it is again apparent that overall the rotary values are somewht lower than the core values in the assay range of 0.07 opt gold or higher.

Table 2. Variation in plus 0.07 opt Au assays, where rotary values are plus 0.07; and where core holes are plus 0.07 opt gold without a corresponding value higher than 0.07 in the rotary hole.

| Hole No. | Rotary hole assay plus 0.07: No. of Samples | Avg.Rot. Higher | No. of Samples | Avg.Rot. Lower | Core hole assay plus 0.07*: No. of Samples | Avg.Rot. Lower |
|---|---|---|---|---|---|---|
| YDDH-1 | 1 | +0.008 | none | N.A. | 1 | -0.090 |
| YDDH-2 | 3 | +0.105 | 5 | -0.039 | 4 | -0.061 |
| YDDH-4 | 2 | +0.080 | 2 | -0.026 | 5 | -0.062 |
| Weighted Average | 6 | +0.081 | 7 | -0.035 | 10 | -0.064 |

* Does not include any values in previous columns.

In the YDDH-4 value table, Miller also includes the rejects of rotary hole YM-75 as part of the checks against both the previous (original) values in the rotary hole and the core hole YD-4. The recheck assays rotary YM-75 are only 0.001 opt gold higher than the core hole values for the total intercept, whereas the original sample was 0.010 opt gold higher. Table 3 compares the values.

Table 3. Comparison of average net difference of recheck rotary assays vs. original rotary assays and core hole YDDH-4.

| Hole No. | No. Samp. | Recheck Rotary Higher than Orig.Rot. | No. Samp. | Recheck Rotary Lower than Orig.Rot. | No. Samp. | Recheck Rotary Higher than Core | No. Samp. | Recheck Rotary Lower than Core |
|---|---|---|---|---|---|---|---|---|
| YDDH-4 | 12 | +0.029 | 8 | -0.023 | 11 | +0.041 | 10 | -0.045 |
| | 1 | same value, no change. | | | | | | |

Σ of all samples x value = 0.004 opt

From the various rechecks submitted, it may be stated that a "nugget" effect is not the result of a large particle isolated in the sample, but rather the irregular distribution of gold within the sample which is not homogenized by the normal splitting and crushing practices used in preparation of the sample.

James D. Sell

JDS:mek
Att.

cc: R.L. Brown/F.T. Graybeal
M.A. Miller

**ASARCO**

Southwestern Exploration Division

April 27, 1990

J.D. Sell

"B" Zone Assay Comparison
RDH vs. DDH Holes
Yarnell Project
Yavapai County, Arizona

As you are aware, we have split and assayed all the core from the four diamond drill holes. The attached tables and histograms attempt to show the relationship in the assay results with both methods of drilling. The data used is "B" zone only. As one can see from the attached tables, there is sometimes considerable variation within the assay intervals even with multiple assays. Variation is shown by plotting the plus (+) or minus (-) change of the RC hole values from the corresponding DDH values.

Several observations can be made from the histograms:

1. The data does not appear to be skewed one way or another. There appears to be equal amounts of plus values as minus values suggesting that drilling techniques do not bias the assays.

2. The largest net difference appears to occur in the higher grade zone suggesting a possible nugget effect.

3. The lag in sample position that occurs in RC drilling may cause a difference in position of the RC samples compared to the diamond drill sample.

4. The difference in position of the holes relative to each other and relative to the ore zone may influence the comparison. Holes 1 and 4 are drilled ~10' updip of the RC hole. Hole 2 is ~10' NE of the RC hole. Hole 3 is 25' NE of the RC hole.

Comparing the entire assay interval (B zone) the results are as follows:

| DDH HOLES (in opt) | RC HOLES (in opt) |
|---|---|
| YDDH-1 | YM-8 |
| 0.041 | 0.041 |
| YDDH-2 | YM-40 |
| 0.070 | 0.062 |
| YDDH-3 | |
| Invalid due to stope intersection and loss of sample. | |
| YDDH-4 | YM-75 |
| 0.056 | 0.066 |

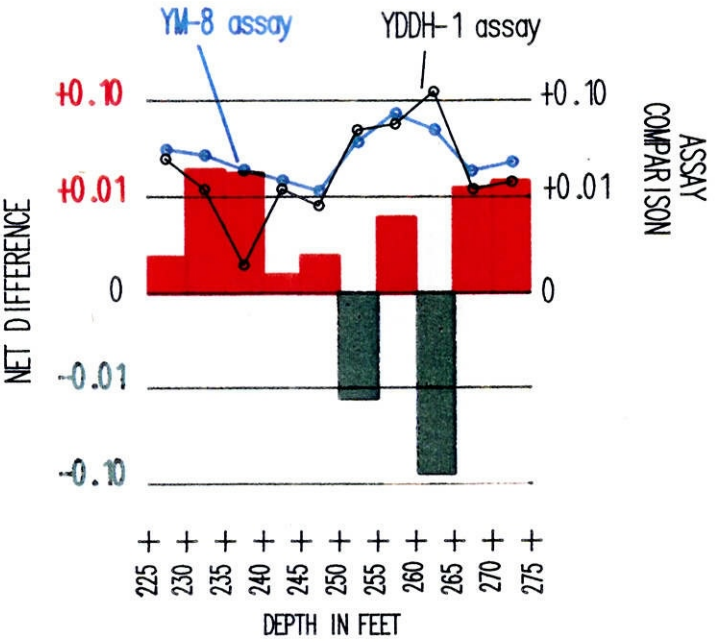
As discussed, DDH results show a fair correlation with the RC holes, but significant differences occur between individual assays.

This study seems to indicate that the RC drilling is reporting the accurate values of the intercept, and does not appear to high grade or low grade the sample. As can be seen from the tables, assay values do show repeatability within a sample interval, but variance does occur; possibly due to a nugget effect.

Mark A. Miller

MAM:mek
Att.

cc: W.L. Kurtz




**ASARCO Incorporated**
**YARNELL PROJECT**

**RCH-DDH ASSAY COMPARISONS**
**YDDH-1 vs YM-8**

**YAVAPAI CO., ARIZONA**

mn 6947MAM/dam tuc 04-27-90
file YAR- 6947dwg

# BULK ASSAY REPORT

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

DATE 1-4-90

COMPANY ASARCO LAB #122889-1

DRILL CORE

PAGE 1

| Sample Description | Ounces per ton AU (gold) | AG (silver) | Remarks |
|---|---|---|---|
| YDDH-1 4-5 | .001 | | |
| " " 5-10 | .006 | | |
| " " 10-15 | .003 | | |
| " " 15-20 | .008 | | |
| " " 17-19 | .009 | | |
| " " 20-25 | .001 | | |
| " " 25-30 | .004 | | |
| " " 30-35 | .001 | | |
| " " 35-36 | .012 | | |
| " " 36-37 | .034 | | |
| " " 37-38 | .134 | | |
| " " 37-39 | .075 | | |
| " " 38-39 | .108 | | |
| " " 39-40 | .195 | | |
| " " 40-41 | .108 | | |
| " " 45-50 | .125 | | |
| " " 50-55 | .015 | | |
| " " 57-59 | .003 | | |
| " " 55-60 | .003 | | |
| " " 60-65 | .002 | | |
| " " 65-70 | .015 | | |
| " " 70-75 | .010 | | |
| " " 77-79 | .018 | | |

Certified Assays When Signed And Dated

1-4-90 [signature]
DATE SIGNATURE

# BULK ASSAY REPORT

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

DATE 1-4-90

COMPANY ASARCO LAB #122889-2

DRILL CORE

PAGE 2

| Sample Description | Ounces per ton AU (gold) | AG (silver) | Remarks |
|---|---|---|---|
| YDDH-1 75-80 | .019 | | |
| " " 80-85 | .008 | | |
| " " 85-90 | .012 | | |
| " " 90-95 | .013 | | |
| " " 97-99 | .006 | | |
| " " 95-100 | .002 | | |
| " " 100-105 | .001 | | |
| " " 105-110 | .006 | | |
| " " 110-115 | .001 | | |
| " " 115-120 | .039 | | |
| " " 117-119 | .014 | | |
| " " 120-125 | .050 | | |
| " " 125-130 | .004 | | |
| " " 130-135 | NO SAMPLE | | |
| " " 135-140 | .013 | | |
| " " 137-139 | .011 | | |
| " " 140-145 | .020 | | |
| " " 145-150 | .011 | | |
| " " 150-155 | .010 | | |
| " " 155-160 | .021 | | |
| " " 157-159 | .033 | | |
| " " 160-165 | .058 | | |
| " " 165-170 | .016 | | |
| " " 170-175 | .017 | | |

Certified Assays When Signed And Dated
1-11-90 [signature]
DATE SIGNATURE

# BULK ASSAY REPORT

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

DATE 1-4-90

COMPANY ASARCO LAB #122889-3

DRILL CORE

PAGE 3

| Sample Description | Ounces per ton AU (gold) | AG (silver) | Remarks |
|---|---|---|---|
| YDDH-1 177-179 | .021 | | |
| " " 175-180 | .008 | | |
| " " 180-185 | .023 | | |
| " " 185-190 | .019 | | |
| " " 190-195 | .017 | | |
| " " 195-200 | .067 | | |
| " " 197-199 | .018 | | |
| " " 200-205 | .013 | | |
| " " 205-210 | .029 | | |
| " " 210-215 | .061 | | |
| " " 217-219 | .017 | | |
| " " 215-220 | .020 | | |
| " " 220-225 | .017 | | |
| " " 225-230 | .043 | | |
| " " 227-229 | .056 | | |
| " " 230-235 | .013 | | |
| " " 235-240 | .003 | | |
| " " 237-239 | .024 | | |
| " " 240-245 | .016 | | |
| " " 242-244 | .017 | | |
| " " 245-250 | .009 | | |
| " " 247-249 | .009 | | |
| " " 250-255 | .065 | | |
| " " 252-254 | .056 | | |

Certified Assays When Signed And Dated
1-4-90 [signature]
DATE SIGNATURE

# BULK ASSAY REPORT

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

DATE 1-4-90

COMPANY ASARCO LAB #122889-4

DRILL CORE

PAGE 4

| Sample Description | Ounces per ton AU (gold) | AG (silver) | Remarks |
|---|---|---|---|
| YDDH-1 255-260 | .079 | | |
| " " 257-259 | .111 | | |
| " " 260-265 | .153 | | |
| " " 262-264 | .084 | | |
| " " 265-270 | .012 | | |
| " " 267-269 | .023 | | |
| " " 270-275 | .019 | | |
| " " 272-274 | .028 | | |
| " " 275-280 | .002 | | |
| " " 280-285 | .004 | | |
| " " 285-290 | .002 | | |
| " " 290-295 | .002 | | |
| " " 295-300 | TR | | |
| " " 300-305 | .001 | | |
| " " 305-310 | .001 | | |
| " " 310-315 | TR | | |
| " " 315-320 | TR | | |
| " " 320-325 | NIL | | |
| " " 325-330 | TR | | |
| " " 330-335 | TR | | |
| " " 335-340 | NIL | | |
| " " 340-345 | .001 | | |
| " " 345-350 | TR | | |

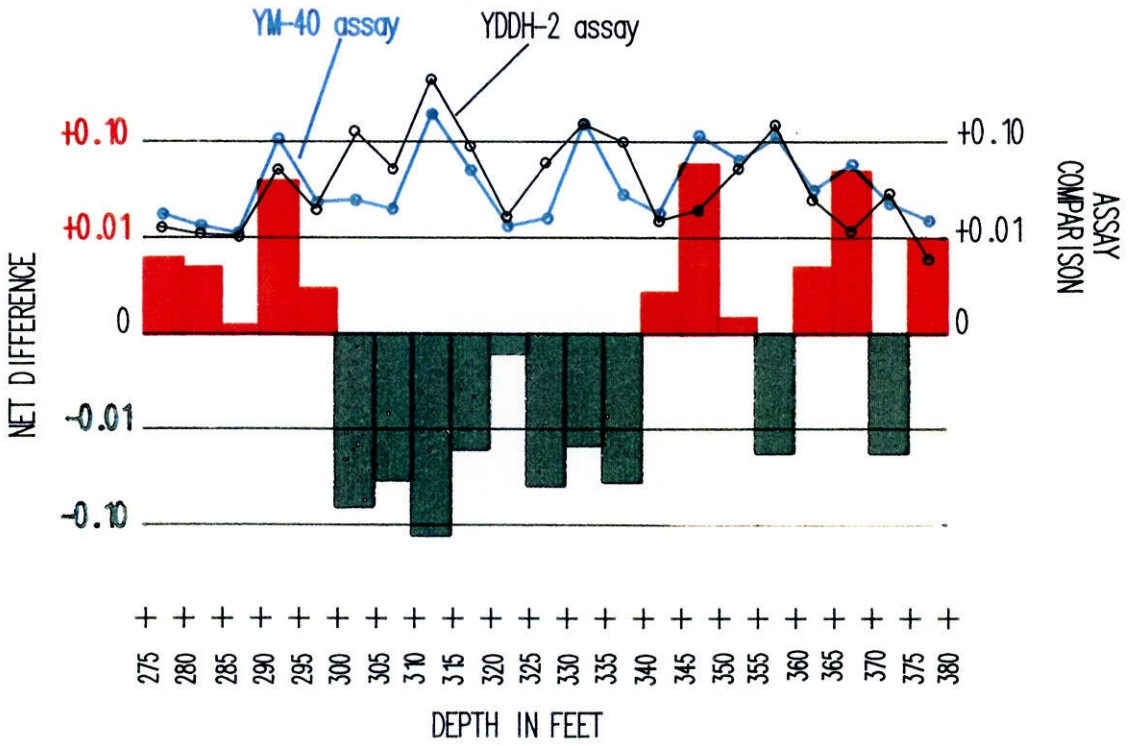
Certified Assays When Signed And Dated
1-4-90
DATE SIGNATURE

"B" Zone Assay Comparison
RDH vs. DDH Holes
Yarnell Project

April 27, 1990

YDDH-1/YM-8
B-Zone Only

| Interval (ft.) | YM-8 (opt Au) | YDDH-1 (opt Au) | Net Difference |
|---|---|---|---|
| 225-230 | .047 | .043 | +.004 |
| 230-235 | .044 | .013 | +.031 |
| 235-240 | .029 | .003 | +.026 |
| 240-245 | .018 | .016 | +.002 |
| 245-250 | .013 | .009 | +.004 |
| 250-255 | .048 | .065 | -.017 |
| 255-260 | .087 | .079 | +.008 |
| 260-265 | .063 | .153 | -.090 |
| 265-270 | .023 | .012 | +.011 |
| 270-275 | .037 | .019 | +.018 |
| Composite Assay 225-275 (in opt Au) | .041 | .041 | |




**ASARCO Incorporated**
**YARNELL PROJECT**

**RCH-DDH ASSAY COMPARISONS**
**YDDH-2 vs YM-40**

**YAVAPAI CO., ARIZONA**

mn 6945 MAM/dam tuc 04-27-90
file YAR- 6945.dwg

"B" Zone Assay Comparison
RDH vs. DDH Holes
Yarnell Project

April 27, 1990

YDDH-2/YM-40
B-Zone Only

| Interval (ft.) | YM-40 | 1G | RC Checks YDDH-2 | DD Hole YDDH-2 | Net Difference |
|---|---|---|---|---|---|
| 275-280 | .023 | .030 | .019 | .015 | +.008 |
| 280-285 | .018 | .020 | .017 | .011 | +.007 |
| 285-290 | .012 | .023 | .095 | .011 | +.001 |
| 290-295 | .129 | .123 | .072 | .067 | +.062 |
| 295-300 | .036 | .045 | .039 | .031 | +.005 |
| 300-305 | .041 | .046 | .080 | .122 | -.081 |
| 305-310 | .027 | .046 | .033 | .077 | -.050 |
| 310-315 | .177 | .168 | .053 | .320 | -.143 |
| 315-320 | .071 | .096 | .091 | .091 | -.020 |
| 320-325 | .013 | .016 | .016 | .015 | -.002 |
| 325-330 | .021 | .045 | .048 | .079 | -.058 |
| 330-335 | .162 | .119 | .544 | .174 | -.012 |
| 335-340 | .043 | .056 | .056 | .099 | -.056 |
| 340-345 | .034 | .046 | .090 | .029 | +.005 |
| 345-350 | .108 | .142* | -- | .029 | +.079 |
| 350-355 | .081 | .108* | -- | .082 | -.001 |
| 355-360 | .131 | .069 | .053 | .152 | -.021 |
| 360-365 | .043 | .042 | .051 | .036 | +.007 |
| 365-370 | .079 | .063 | .077 | .013 | +.066 |
| 370-375 | .033 | .063 | .042 | .046 | -.013 |
| 375-380 | .018 | .026 | .011 | .008 | +.010 |
| Composite Assays 275-380 (in opt Au) | .062 | .066 | .080 | .070 | |

*(pulps)

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-14-90

**COMPANY** ASARCO LAB #031390-1

ROTARY CUTTINGS

PAGE 1

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 2 0-4 | .019 | | |
| " " 4-9 | .017 | | |
| " " 9-14 | .095 | | |
| " " 14-19 | .072 | | |
| " " 19-24 | .039 | | |
| " " 24-29 | .080 | | |
| " " 29-34 | .033 | | |
| " " 34-39 | .053 | | |
| " " 39-44 | .091 | | |
| " " 44-49 | .016 | | |
| " " 49-54 | .048 | | |
| " " 54-59 | .544 | | |
| " " 59-64 | .056 | | |
| " " 64-69 | .090 | | |
| " " 69-74 | .053 | | |
| " " 74-79 | .051 | | |
| " " 79-84 | .077 | | |
| " " 84-89 | .042 | | |
| " " 89-94 | .011 | | |
| " " 254-259 | .006 | | |
| " " 255-260 | .004 | | |
| " " 259-264 | .010 | | |
| " " 260-265 | .003 | | |
| " " 264-269 | .002 | | |
| " " 265-270 | .003 | | |

Certified Assays When Signed And Dated

3-14-90 DATE

SIGNATURE

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-14-90

**COMPANY** ASARCO LAB #031390-2

ROTARY CUTTINGS

PAGE 2

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 2 269-274 | .005 | | |
| " " 270-275 | .003 | | |
| " " 275-280 | .015 | | |
| " " 280-285 | .011 | | |
| " " 285-290 | .011 | | |
| " " 290-295 | .067 | | |
| " " 295-300 | .031 | | |
| " " 300-305 | .122 | | |
| " " 305-310 | .077 | | |
| " " 310-315 | .320 | | |
| " " 315-320 | .091 | | |
| " " 320-325 | .015 | | |
| " " 325-330 | .079 | | |
| " " 330-335 | .174 | | |
| " " 335-340 | .099 | | |
| " " 340-345 | .079 | | |
| " " 345-350 | .029 | | |
| " " 350-355 | .082 | | |
| " " 355-360 | .152 | | |
| " " 360-365 | .036 | | |
| " " 365-370 | .013 | | |
| " " 370-375 | .046 | | |
| " " 375-380 | .008 | | |
| " " 380-385 | .004 | | |
| " " 385-390 | .003 | | |

Certified Assays When Signed And Dated
3-14-90 [illegible]
DATE SIGNATURE

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-14-90

**COMPANY** ASARCO LAB #031390-3

ROTARY CUTTINGS

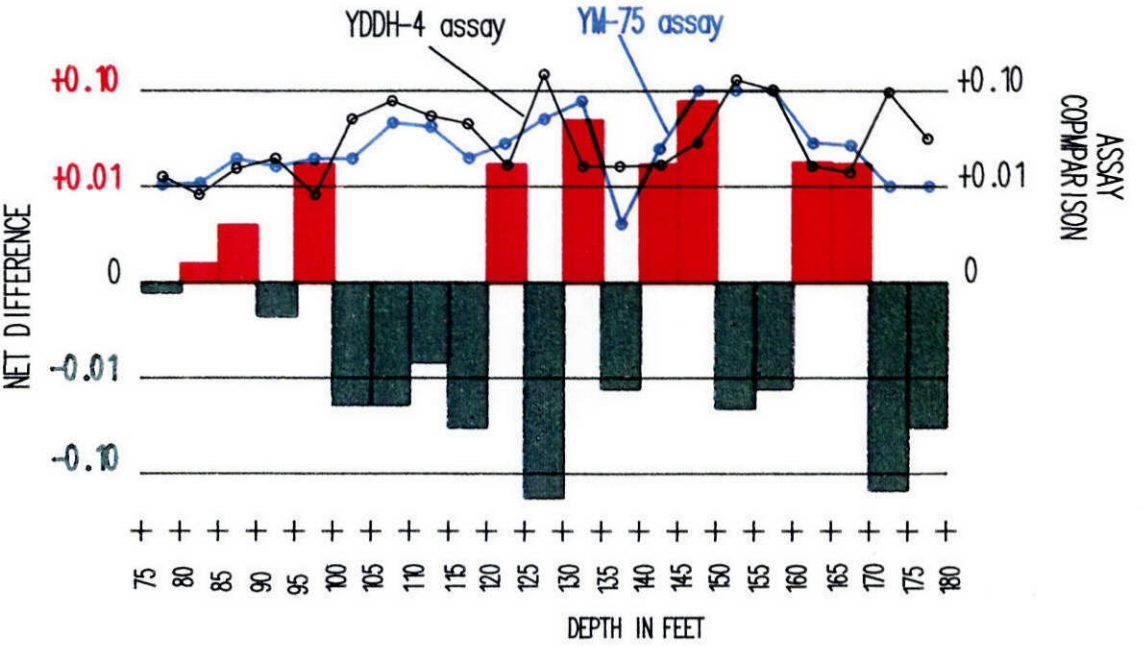
PAGE 3

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 2 390-395 | .004 | | |
| " " 395-400 | .007 | | |
| | | | |
| YDDH - 3 124-129 | .010 | | |
| " " 125-130 | .003 | | |
| " " 129-134 | .014 | | |
| " " 130-135 | .045 | | |
| " " 134-139 | .011 | | |
| " " 135-140 | .024 | | |
| " " 139-144 | .039 | | |
| " " 140-145 | .020 | | |
| " " 144-149 | .009 | | |

Certified Assays When Signed And Dated

3-14-90 Greg R. Eddleman

DATE SIGNATURE




**ASARCO Incorporated**
**YARNELL PROJECT**

**RCH-DDH ASSAY COMPARISONS**
**YDDH-4 vs YM-75**

**YAVAPAI CO., ARIZONA**

mn 6946 MAM/dam tuc 04-27-90
file YAR- 6946dwg

"B" Zone Assay Comparison
RDH vs. DDH Holes
Yarnell Project

April 27, 1990

YDDH-4/YM-75
B-Zone Only

| Interval ( ft.) | YM-75 | RC Checks YDDH-4 | DDH YDDH-4 | Net Difference |
|---|---|---|---|---|
| 75-80 | .011 | .010 | .012 | -.001 |
| 80-85 | .011 | .011 | .009 | +.002 |
| 85-90 | .026 | .047 | .020 | +.006 |
| 90-95 | .021 | .031 | .025 | -.004 |
| 95-100 | .035 | .048 | .009 | +.026 |
| 100-105 | .037 | .048 | .071 | -.034 |
| 105-110 | .062 | .073 | .095 | -.033 |
| 110-115 | .064 | .028 | .076 | -.012 |
| 115-120 | .024 | .079 | .067 | -.043 |
| 120-125 | .047 | .056 | .021 | +.026 |
| 125-130 | .067 | .076 | .190 | -.123 |
| 130-135 | .088 | .008 | .021 | +.067 |
| 135-140 | .006 | .189 | .024 | -.018 |
| 140-145 | .043 | .046 | .022 | +.021 |
| 145-150 | .138 | .105 | .045 | +.093 |
| 150-155 | .118 | .103 | .155 | -.037 |
| 155-160 | .110 | .103 | .125 | -.015 |
| 160-165 | .051 | .061 | .020 | +.031 |
| 165-170 | .045 | .057 | .018 | +.027 |
| 170-175 | .010 | .005 | .111 | -.110 |
| 175-180 | .010 | .004 | .047 | -.046 |
| Composite Assays 105-170 (in opt Au) | .066 | .057 | .056 | |

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-16-90

**COMPANY** ASARCO LAB #031590-1

DRILL CORE

PAGE 1

| Sample Description | Ounces per ton AU (gold) | AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 4 139-144 | .046 | | |
| " " 140-145 | .022 | | |
| " " 144-149 | .105 | | |
| " " 145-150 | .045 | | |
| " " 149-154 | .103 | | |
| " " 150-155 | .155 | | |
| " " 154-159 | .103 | | |
| " " 155-160 | .125 | | |
| " " 159-164 | .061 | | |
| " " 160-165 | .020 | | |
| " " 164-169 | .057 | | |
| " " 165-170 | .018 | | |
| " " 169-174 | .005 | | |
| " " 170-175 | .111 | | |
| " " 174-179 | .004 | | |
| " " 175-180 | .047 | | |
| YDDH - 2 54-59 | .368 | REFIRE | |

Certified Assays When Signed And Dated

3-16-90 [signature]

DATE SIGNATURE

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-15-90

**COMPANY** ASARCO LAB #031490-2

DRILL CORE

PAGE 2

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 3 225-230 | .095 | | |
| " " 229-234 | .036 | | |
| " " 230-235 | .019 | | |
| " " 234-239 | .044 | | |
| " " 235-240 | .008 | | |
| " " 240-245 | .038 | | |
| " " 245-250 | .110 | | |
| " " 250-255 | .012 | | |
| " " 255-260 | .004 | | |
| " " 260-265 | .004 | | |
| " " 265-270 | .008 | | |
| " " 270-275 | .004 | | |
| " " 275-280 | .015 | | |
| | | | |
| YDDH - 4 74-79 | .010 | | |
| " " 75-80 | .012 | | |
| " " 79-84 | .011 | | |
| " " 80-85 | .009 | | |
| " " 84-89 | .047 | | |
| " " 85-90 | .020 | | |
| " " 89-94 | .031 | | |
| " " 90-95 | .025 | | |
| " " 94-99 | .048 | | |
| " " 95-100 | .009 | | |
| | | | |

Certified Assays When Signed And Dated

3-16-90 DATE

SIGNATURE

**BULK ASSAY REPORT**

**TRIAD MINERALS CO.**
ASSAYING & CONSULTING
P.O. Box 2754 - Mile Post 115, Hwy. 89
Wickenburg, Arizona 85358
602-684-3816

**DATE** 3-15-90

**COMPANY** ASARCO LAB # 031490-3

DRILL CORE

PAGE 3

| Sample Description | Ounces per ton AU (gold) | Ounces per ton AG (silver) | Remarks |
|---|---|---|---|
| YDDH - 4 99-104 | .048 | | |
| " " 100-105 | .071 | | |
| " " 104-109 | .073 | | |
| " " 105-110 | .095 | | |
| " " 109-114 | .028 | | |
| " " 110-115 | .076 | | |
| " " 114-119 | .079 | | |
| " " 115-120 | .067 | | |
| " " 119-124 | .056 | | |
| " " 120-125 | .021 | | |
| " " 124-129 | .076 | | |
| " " 125-130 | .190 | | |
| " " 129-134 | .008 | | |
| " " 130-135 | .021 | | |
| " " 134-139 | .189 | | |
| " " 135-140 | .024 | | |

Certified Assays When Signed And Dated

3-18-90 DATE

SIGNATURE

copies for: JDS WLK SLL File

# NORGOLD RESOURCES INC.


U.S. OFFICES:
13935 Chamy Drive
Reno, Nevada
89511
(702) 851-3177
Fax: (702) 851-3177

HEAD OFFICE:
210 - 475 Howe Street
Vancouver, B.C.
V6C 2B3
(604) 681-5566
Fax: (604) 687-8789


May 25, 1990

ASARCO Incorporated

MAY 29 1990

SW Exploration

Mr. James D. Sell, Manager
Southwest District Exploration
ASARCO, Inc.
P. O. Box 5747
Tucson, Arizona 85703

Dear Jim:

Tench Page, Bob Schafer and I thank you for the excellent tour of the Yarnell property you provided us on May 14. The tour was informative, especially for Bob and me, who have no background with this project.

As we discussed, Norgold is currently making a substantial effort to become more familiar with the project, and we need additional technical data. Specifically, we would like for ASARCO to provide us with copies of all surface and underground sampling results, all metallurgical reports which have been completed to date and the Kilborn engineering report. Would you please have this material delivered to my home address (368 Cameron Circle, San Ramon, California 94583). If you are unable to authorize the release of this information to Norgold, please forward this request to the appropriate person. If needed, I can be reached at my home telephone, (415) 829-3451.

Again, Jim, thanks for the tour. We look forward to working with you and the others at ASARCO as the Yarnell project progresses.

6-15-90
RLB says project turned over to Mining West. Thus so thru
SC Lakosky 309

Sincerely yours,

Steve

Steven C. Potter
President
Norgold Resources (U.S.) Inc.

cc: M. Philpot
R. Graeme

LAW OFFICES
FENNEMORE CRAIG
A PROFESSIONAL CORPORATION

PHOENIX, ARIZONA 85004-2390
(602) 257-8700

JDS

May 29, 1990

ASARCO Incorporated
180 Maiden Lane
New York, New York 10038

ATTN: Augustus B. Kinsolving, Esq.

OUR FILE NO. JWJ 12194

FEDERAL IDENTIFICATION No. 86-0293128

PLEASE RETURN THIS PORTION OF STATEMENT WITH YOUR REMITTANCE

Summary Sheet for Southwestern Mining Division

For legal services and disbursements rendered during the period from April 1, 1990 through April 30, 1990 per the attached schedule.

| | | |
|---|---|---|
| | Arizona Surface Water Quality Standards (12194.066) | $16,863.39 |
| 202-524 | Yarnell Gold Mine, Environmental Permitting (12194.052) | 1,023.59 |
| 444-04 | Mission Landfill Compliance Issue/Environmental (12194.076) | 625.40 |
| 620-753 | Mission Complex - Hazardous Waste Investigation (12194.074) | 452.40 |
| | Silver Bell Environmental Issues, General Legislative (12194.053) | 463.10 |
| | TOTAL FEES & DISBURSEMENTS SOUTHWESTERN MINING DIVISION | $19,427.88 |

COPY

ASARCO Incorporated
OCT 3 1990
SW Exploration

ASARCO

Southwestern Exploration Division

JDS

May 29, 1990

Yarnell Proj.

FILE NOTE

Copperstone Visit
AZ AIME Geology Section
La Paz County, Arizona

On Saturday, May 26, 1990, the Arizona AIME, Geology Section had their annual meeting at the Cyprus Copperstone mine. M.A. Miller, J.D. Rasmussen, J.J. Malusa, and J.D. Sell attended from Asarco.

Both the geologist and the mine manager talked openly on the problems and successes at Copperstone. Miller will be writing on his impressions.

Copperstone has about two years reserves left and intends to shut down quickly.

Several items that may be of interest and applied to the Yarnell Project.

1. The initial drill spacing was 140 feet along strike and 100 feet down dip. Although some surprises were found in mining -- such as, more offset faulting and misinterpretation of high-angled veins in rotary cuttings which happened to project along trend of their shallow dipping structure, but the overall grade wasn't there when they stripped down to it (the shallow-dipping structure had been offset into the hanging wall side), the staffs note of interest was that the down-dip side of the deposit, where the high-wall is slated to be, should be closely drilled so as to pin that high-wall down early on for pit configuration. They have left some mineral that should have been taken, but the high-wall is 50 feet short and present economics says they can't move that 50' slot now.

2. They have spent in excess of $700,000 in mesh, etc., to cover their leach pads for protection against the loss of bird life. The end result for best results was a grid of steel cables 16' x 24' over the pond, with 16' x 2000' mesh strips clipped to the cables. This arrangement was simple, and easily repairable. Cost of 27 cents per ton of pond material. They would probably place the cables on floating barrels, rather than posts, on any new pond.

3. On the waste dumps, they have put them at various final elevations to break-up the skyline effect. Also, they are loose dumping the last lift and not leveling this out (they rip the next to last surface first). They have found that these bumpy and loose piles are capable of handling a 100-year flood input, whereas on the leveled surface, such a rain would run off and have to be contained outside the dump area.

4. Another item was the final detoxification and cover on the leach ponds. Originally, they were going to dry them, then cover with waste rock. The time element and cost is no small item. Now their plans are to run sand and chlorine through the mill and place on the leach ponds. The chlorine will kill the cyanide, and the sand will cover the ponds. They believe they'll have the ponds EPA clean in two or three months of such activity -- some years time saved.

A 1989 Annual Report was all they handed out.

James D. Sell

JDS:mek

cc: W.L. Kurtz
S.L. Lakosky
D.E. Crowell
M.A. Miller

ASARCO

Mineral Beneficiation Department
Tucson, Arizona

May 29, 1990

FILE MEMORANDUM - YARNELL 3.1

Bottle Roll Tests on Yarnell
Diamond Drill Core Rejects

Listed below are the results of the bottle roll leach tests on diamond drill core rejects at 1/4-inch size. There is very little difference in recoveries between the three holes, and the results closely check the bottle roll test on the HG/LG composite (62.8% recovery) used for previous testwork. These results are lower than the 72% recovery obtained with column tests which is probably due to the slow leaching characteristics of this ore. Test data indicates that leaching was still continuing when the tests were terminated. We should definitely proceed with the small column tests with these samples to determine the effect of longer leach times.

Bottle Roll Tests on Diamond Drill Rejects

| Hole No. | Calc. Head Assay | 96-Hour Leach Recovery |
|---|---|---|
| YDDH-1 | 0.043 opt Au | 67.4% |
| YDDH-2 | 0.051 opt Au | 64.7% |
| YDDH-4 | 0.047 opt Au | 61.7% |

We also have preliminary results from the column leach test at 1-1/2 inch size after nine days leaching and, as expected, results are somewhat better than the 2-inch tests at comparable times (assuming equal heads).

D. E. Crowell

DEC:brw
cc: R. J. Kupsch
T. E. Scartaccini
S. L. Lakosky
J. D. Sell
W. L. Kurtz

ASARCO Incorp.

MAY 30 1990

SW Exploration

JDS

# ASARCO

ASARCO Incorporated

JUN 4 1990

SW Exploration

Exploration Department
Frederick T. Graybeal
Chief Geologist

May 31, 1990

ASARCO Incorporated

JUN 4 1990

SW Exploration

Mr. J. D. Sell
Tucson Office

Results of Twinned Reverse
Circulation-Diamond Drill Holes
Yarnell Project, Arizona

Dear Mr. Sell:

I have reviewed your May 24, 1990 cover letter to Mr. Miller's April 27, 1990 comparison of assays between twinned diamond drill and reverse circulation drill holes. As I recall there were two reasons for the diamond drilling. The first was to obtain geological information relative to ore controls and continuity of mineralization. The second was to twin (within five or ten ft.) previous reverse circulation holes to confirm assays. Your cover letter notes that reverse circulation holes are consistently lower than diamond drill twins, and this relationship holds both for averages across the entire hole and assays at 0.07 oz Au or above. Do you think that this is a relationship repeatable throughout the entire Yarnell deposit or is the relationship simply apparent needing further statistical comparison? Remember that the diamond drill locations were twins of the RC holes for the purpose of confirming assays. It is not clear that we did confirm the RC assays. If not, which one is correct and which should be used for ore reserve purposes? This is a financially thin project; we should be accurate on all points. Mr. Miller seems to conclude assays checked closely. Who is right?

With regard to your "reject" assays, it's not entirely clear what you are checking. You seem to draw the conclusion from a review of the reject assays that an apparent nugget effect is instead an irregular distribution of gold within a sample not homogenized during sample preparation, but it still isn't clear how you drew this conclusion and whether the differences that you found aren't part of the normal imprecision in the fire assay procedure at low absolute levels of gold.

Mr. Miller's report states that four diamond drill holes were completed but results of only three are attached. His observation #2 refers to a net difference between the two drill samples in higher grade ranges but he

doesn't say net of what. Clearly, the net difference in higher range on absolute basis would be greater than the net difference in the low range at identical levels of precision. Net difference on a percentage basis at different assay ranges may be a clue to the presence of nuggets. In his observation #3 he refers to a lag in sample position in RC versus diamond drill samples, but I'm not clear as to what he means by lag. Observation #4 seems to continue observation #3, but it seems the comparisons of individual assays between adjacent drill holes is a function of collar elevation and position of the assay within the Yarnell fault zone. Mr. Miller thought that the position within the Yarnell fault zone of adjacent holes might of been different; he could of adjusted those assays and determined whether or not correcting for collar elevation was necessary.

Finally, Mr. Miller seems to conclude that the RC drilling "reports the accurate values of the intercept", but it seems to me that the diamond drill sample also accurately portrays its intercept. The diamond drill sample is smaller, which may result in the assay pattern for diamond drill samples being more erratic. It is not clear that Mr. Miller did a standard deviation of RC and diamond drill samples to see whether sample size might correlate with erratic assay distributions and, therefore, it's not clear to me that the RC samples are more accurate. Further, if Miller concludes there is no significant difference between diamond drill and reverse circulation samples (which he does), how can he then conclude the latter are more accurate?

We all tend to prefer RC samples because they are larger and as a result sample patterns are usually less erratic and easier to project between drill holes for ore reserve purposes. However, if there is a consistent bias one way or another using a drilling technique, then further thought as to the reason for that relationship is required. What I might have expected was that the diamond drill and RC assays check on an absolute basis averaging across the entire hole, but that the diamond drill assays were overall much more erratic because of the smaller sample size. Your summary reports that Miller concludes that "totals of the individual holes" (whatever that seems to mean) vary no more than 0.01 oz Au. Your conclusion (2nd ¶) is that the averages of the entire holes show that the rotary hole assays are either half of the core holes

or 0.02 oz Au lower (your wording is unclear). Whichever is your meaning, either is a significant difference, and I would like to know why the difference exists and then your recommendation regarding what we should do about it.

Very truly yours,

F. T. Graybeal

F. T. Graybeal

FTG:mc

JDS

APKER, APKER, HAGGARD & KURTZ, P.C.
P. O. Box 10280
Phoenix, Arizona 85064-0280
(602) 381-0085

Exploration Department
Southwestern U.S. Division
ASARCO Incorporated
P.O. Box 5747
Tucson, Arizona 85703-0747

June 1, 1990
Page 1
Client: 111
Matter: 12

Matter: Re: Norgold Resources, Inc.

| Date | Professional Services Rendered |
|---|---|
| 05/25/90 | Review Norgold agreement; telephone conference with Mr. Kurtz re right of Asarco to sell its interest. |
| 05/30/90 | Telephone conference with Mr. Gay; review BLM recording regulations. |
| 05/31/90 | Telephone conference with Mr. Gay re assessment work and filing requirements. |

Total Services 510.00

444-04

COPY

VANCOUVER STOCK EXCHANGE-INCENTIVE OPTIONS

FROM: W. L. KURTZ 6/11/90

TO: J. D. Sell YARNELL

Mr Brown asks:

(1) Progress on patenting the ore claim

(2) Progress final ore reserve

FROM: W. L. KURTZ 6/11/90

TO: J. D. Sell YARNELL

Mr Brown asks:

(1) Progress on patenting the ore claim

(2) Progress final ore reserve report.

Keep moving on this.

ASARCO

Southwestern Mining Department

ASARCO Inc.
JUN 1 1 1990
SW Exploration

June 11, 1990

MEMORANDUM

TO: T. E. Scartaccini

FROM: S. L. Lakosky

RE: Yarnell Project Mine Closure Costs

Per your request, the following is an explanation and update of the estimated mine closure costs and feasibility of the Yarnell Project.

The mine closure costs listed in the Yarnell Project Feasibility Study dated April 4, 1990 were as follows:

| | |
|---|---|
| Mine/Crush Contractor Demobilization | $150,000 |
| Heap & Pond Neutralization | 50,000 |
| Heap Capping | 250,000 |
| Waste Dump Capping | -0- |
| Pit Fencing | 20,000 |
| Contingency | 47,000 |
| Total | $517,000 |

REVIEW & REVISION

MINE/CRUSH CONTRACTOR DEMOBILIZATION

This estimate was derived from contractor's ± 10% budgetary quotations and it needs no revision.

HEAP & POND NEUTRALIZATION

This estimate was based on recirculating solution through the heap for a period of 12-18 months to detoxify the heap and ponds. This estimate needs no revision.

HEAP CAPPING

During compilation of data for the Feasibility Study, I referenced a 1988 Society of Mining Engineers publication titled "Introduction To Evaluation, Design and Operation of Precious Metal Heap Leaching Projects" by Van Zyl, Hutchinson and Kiel. This publication states that the average cost of heap dump

reclamation at current operations is approximately $0.25 per ton of ore. Using this basis, the capping cost estimate for the 3,928,000 ton ore reserve would equal $982,000 or approximately $32,000 per acre for the 31 acre heap and pond area. Because this reclamation cost per acre estimate was 4 times higher than Mission's historical reclamation cost of $8,000 per acre, I chose instead to use Mission's numbers in the Yarnell estimate. The feasibility report as written included 31 acres at $8,000 per acre for a heap dump and pond capping and revegetation total cost of $250,000.

After reconsideration, the Yarnell reclamation cost per acre should probably be increased 50% above Mission's figure of $8,000 per acre to account for the fact that on-site capping material is not available and would have to be purchased and hauled from the Peeples Valley area, located about 6 miles north of the project area. Using the revised estimate of $12,000 per acre, the cost of capping and revegetating the 31 acre Yarnell heap dump and solution pond surface area is $372,000.

WASTE DUMP CAPPING

During the presentation of the Yarnell Project to the Management Committee on May 30, 1990, the suggestion was made that due to the close proximity of the project to the highway and nearby community, we should incorporate from the beginning, a plan to cap and revegetate the most visible areas of disturbance. The proposed strategy would be to let the nearby residents know prior to the permitting process, what the area will look like when the project is complete.

The cost of capping and revegetating approximately 40 acres of waste dump, haul road, truck shop and plant area at $12,000 per acre is $480,000.

PIT FENCING

The deposit is located within an area of significant topographic relief. Returning to a more natural condition that portion of the ultimate pit wall which would be visible to the nearby community of Glen Ilah, would not be impossible, but would certainly be too expensive for such a fragile project. For this reason it was assumed that the pit area would be fenced with used chain link material for $20,000.

UPDATED AND REVISED YARNELL PROJECT MINE CLOSURE COSTS

| | |
|---|---|
| Mine/Crush Contractor Demobilization | $150,000 |
| Heap & Pond Neutralization | 50,000 |
| Heap & Pond Capping | 372,000 |
| Waste Dump Capping | 480,000 |
| Pit Fencing | 20,000 |
| Contingency at 10% | 107,000 |
| Total | $ 1,179,000 |

CONCLUSION

Due to a more comprehensive capping and revegetation scenario than was contained in the Feasibility Study, and due to revised costs of capping and revegetation, the current estimate for mine closure costs is $1,179,000 rather than the $517,000 figure used in the Feasibility Study.

Using the revised mine closure costs, the Yarnell Project feasibility is as follows:

YARNELL PROJECT
DCFROI (%)
(WITH REVISED MINE CLOSURE COSTS)

| GOLD PRICE | PROJECT | ASARCO'S PORTION OF NORGOLD'S VARIOUS OPTIONS | | |
|---|---|---|---|---|
| $/OZ | 100% BASIS | 51/49JV | NET PROFITS | MINING LEASE |
| 450 | 30.2 | 28.1 | 21.7 | 21.8 |
| 425 | 20.9 | 19.4 | 12.3 | 13.8 |
| 400 | 10.7 | 9.9 | 2.0 | 5.4 |
| 375 | (0.2) | (0.3) | (10.4) | (3.5) |
| 350 | (12.5) | (11.6) | (30.8) | (20.5) |

S. L. Lakosky
S. L. Lakosky
Mine Superintendent
Mission Unit

SLL/kh
Attach.

cc: RJKupsch
RLBrown
KRMorano
DECrowell
WLKurtz
JDSell[redacted]
File

Y-3.0

JDS

**ASARCO**

Southwestern Mining Department

June 12, 1990

ASARCO Incorporated

JUN 13 1990

SW Exploration

MEMORANDUM

TO: T. E. Scartaccini

FROM: S. L. Lakosky

RE: Yarnell Project Exploration and Option Payments

Per the Asarco/Norgold Exploration and Option Agreement dated January 31, 1989, and subject to the right of Asarco to terminate said Agreement by providing Norgold 30 days advance notice of such termination, Asarco is obligated to make the following additional option payments on or before the Agreement expiration date of July 1, 1991:

| PAYEE | AMOUNT | 30 DAY ADVANCE NOTICE OF TERMINATION DEADLINE (Before) | PAYMENT DUE (On or Before) |
|---|---|---|---|
| Heintzelman | $ 5,000.00 | 5-30-90 | 6-30-90 June |
| Norgold | 20,000.00 | 6-1-90 | 7-1-90 |
| Western Building and Mining Co. | 100,000.00 | 9-1-90* | 1-1-91 |
| Heintzelman | 12,500.00 | 11-30-90 | 12-31-90 Dec '90 |
| Norgold | 25,000.00 | 12-1-90 | 1-1-91 |
| Layton | 25,000.00 | 3-21-91 | 4-21-91 |
| Heintzelman | 12,500.00 | 5-30-91 | 6-30-91 |
| Norgold | 25,000.00 | 6-1-91 | 7-1-91 |
| Total | $225,000.00 | | |

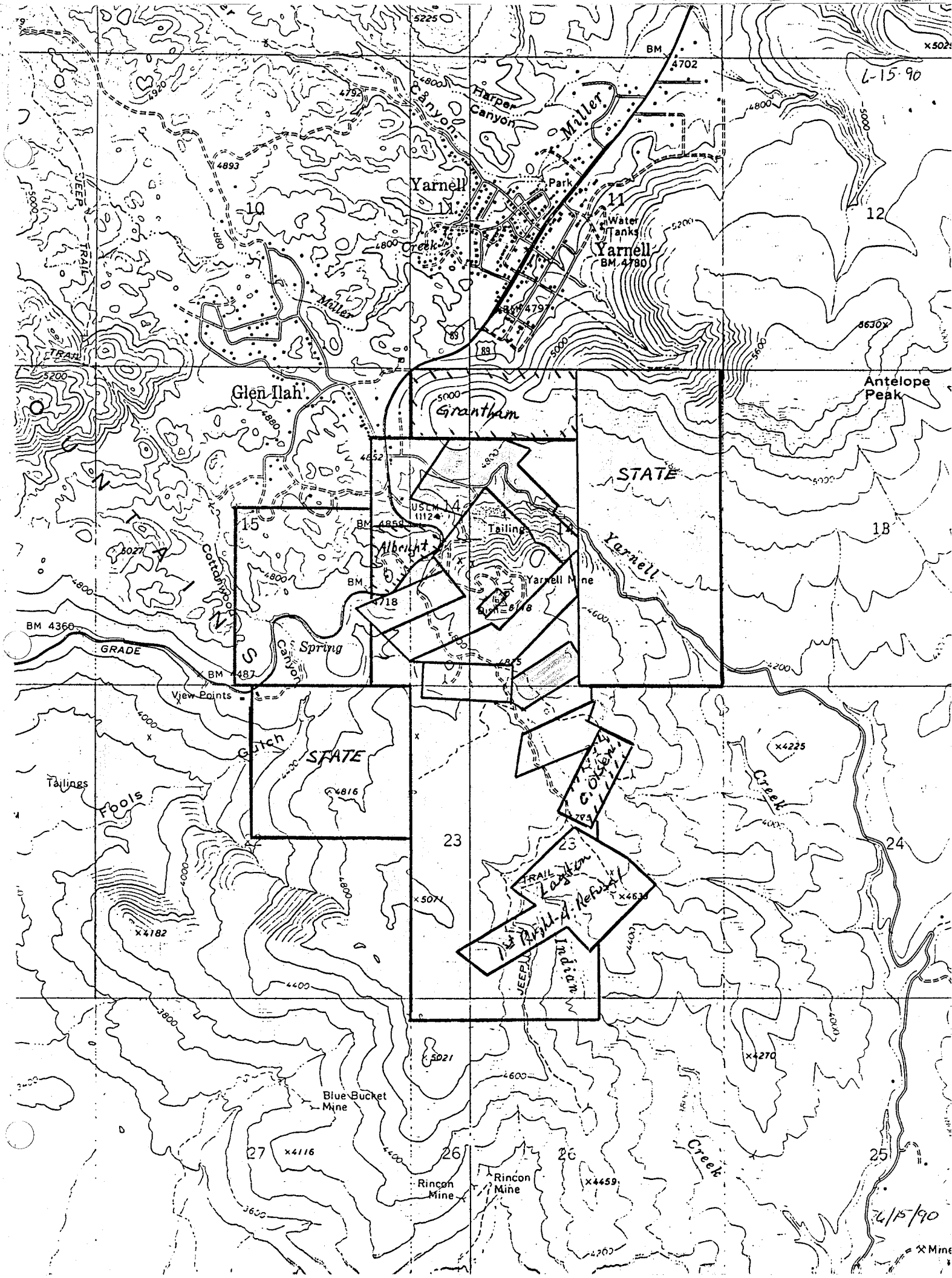
* Even if Asarco provides Norgold with advance notification of termination of the Exploration and Option Agreement before 9-1-90, Asarco must also notify Norgold before 10-1-90 that Asarco doesn't intend to make the 1-1-91 payment to Western Building and Mining Co., otherwise, Asarco will still be obligated to make such payment.

S. L. Lakosky

S. L. Lakosky
Mine Superintendent
Mission Unit

SLL/kh

cc: RJKupsch
RLBrown
KRMorano
DECrowell
WLKurtz
JDSell
File


L-15-90
Harper Canyon
Miller
Canyon
Yarnell
Park
Water Tanks
Yarnell
BM 4780
Creek
Miller
JEEP TRAIL
Glen Ilah
Grantham
Antelope Peak
STATE
Yarnell
Tailings
Albright
Yarnell Mine
Cottonwood
Canyon
Spring
GRADE
View Points
Gulch
STATE
Tailings
Fools
Creek
Lagdon
Indian
Creek
Blue Bucket Mine
Rincon Mine
Rincon Mine
6/15/90

JDS

# FACSIMILE TRANSMISSION

DATE: June 14, 1990

TO: ASARCO

ATTENTION: Jim Sell

TOTAL NO. OF PAGES: 3 (including this page)

FROM: Michael Philpot NORGOLD RESOURCES

Suite 206/210 - 475 Howe Street
Vancouver, B.C.
V6C 2B3 Canada

Telephone: (604) 681-5566

Facsimile No.: (604) 687-8789

ASARCO Inc p

JUN 14 1990

SW Exploration

* * * * * * * * * * * * * * * *

IF THIS TRANSMISSION IS NOT FULLY OR LEGIBLY RECEIVED

PLEASE TELEPHONE (604) 687-4144

OPERATOR: _____

NOTES:

Enclosed is the documentation with regards to the Company State Lease 08-96981 which covers the balance of land in Sec 22 T10N R5W

Please forward a land map and description of property that ASARCO / NORGOLD have in the joint venture. I need whatever you have A.S.A.P. (ie today) Thanks Michael

P.P. No. [redacted]

Effective Date December 6, 1989

# STATE LAND DEPARTMENT
# STATE OF ARIZONA
# PROSPECTING PERMIT

JUN 14 1990
SW Exploration

The STATE OF ARIZONA grants to NORGOLD RESOURCES, INC.

_____, the exclusive right, for a

period of one (1) year from date, subject to renewals as hereinafter set forth, but in no event beyond the 5th day of December, 19 94,

to prospect for minerals on the State land hereinafter described upon the following expressed conditions which are a part of the permit.

1. The permittee shall have those surface rights necessary for the prospecting and exploration for mineral, but may remove from the land only that amount of mineral required for sampling, assay and metallurgical testing purposes.

2. The permittee shall have the right of ingress to and egress from the land covered by the permit but only along routes first approved by the State Land Commissioner.

3. The permittee shall be liable to and shall compensate the owner and lessee of the surface of the State land covered by this permit, or across which the permittee exercises the right of ingress and egress, for any loss to such owner and lessee from damage or destruction caused by the permittee, his or its agents or employees, to grasses, forage, crops or improvements upon such State land.

4. This permit shall terminate automatically, as of the end of any annual period from and after the date of issuance thereof unless during such annual period the permittee shall have expended in exploration for valuable mineral deposits on the State land covered by this permit the prescribed amount per acre, file an application for renewal and submit proof of the amount expended on exploration. The amount to be expended during each of the first two annual periods in which this permit may be in effect shall not be less that ten dollars for each acre of land covered by this permit at the commencement of such annual period, and the amount to be expended during each of the last three annual periods in which this permit may be in effect shall be not less than twenty dollars for each acre covered by this permit at the commencement of such annual period.

5. Prior to the termination of any annual period, the permittee may file a release with the State Land Department, releasing acreage covered by this permit provided that the acreage released be contained within one or more rectangular subdivisions of twenty acres more or less, or lots, according to the lines of the public survey.

6. Upon any partial or total relinquishment, or the cancellation or expiration of the permit, other than by issuance of mineral lease, the permittee shall fill any holes, ditches, or other excavations as may be required by the State Land Commissioner and so far as reasonably possible, restore the surface to its former conditions.

DESCRIPTION OF LAND UNDER PERMIT CONTAINED IN SUPPLEMENT ATTACHED HERETO AND MADE A PART HEREOF.

# STATE OF ARIZONA
## LAND DEPARTMENT

| MO | DAY | YR. |
|---|---|---|
| 13 | 06 | 89 |

NORBOLD RESOURCES INC
P O BOX 12182
VANCOUVER BC
CANADA V6E4N8

| KE | LEASE NUMBER | |
|---|---|---|
| 08 | 94751 | 00 |

| COUNTY | LOCATION SEC. | TOWNSHIP | RANGE | DESCRIPTION | ACRES | BEGINNING | FUND |
|---|---|---|---|---|---|---|---|
| 13 | 29 | 10.0 N | 05.0 W | LOTS 1 2 4 32 SENW | 458.05 | | 031 04 |

LESSEE SIGNATURE: [signature]

DATE: JANUARY 3RD 1990

TOTAL ACREAGE: 458.05

COMMISSIONER: By Ramon J Fierro

DATE: 1-23-90

(This permit is issued in duplicate)
20-72

(Sign Here) [signature]
Permittee

JDS

**ASARCO**

**Southwestern Exploration Division**

June 15, 1990

W.D. Gay

Pennsylvania Claim
Patent Proceedings
Yarnell Project
Yavapai County, AZ

As we verbally discussed, you are to proceed with the patenting procedures for the Pennsylvania unpatented claim at the Yarnell Project, Yavapai County, Arizona.

I attach Mr. Miller's note to you showing the drill holes and their intercepts on the Pennsylvania claim.

James D. Sell

James D. Sell

JDS:mek
Att.

cc: R.L. Brown
W.L. Kurtz
S.L. Lakosky

**ASARCO**

Southwestern Exploration Division

May 2, 1990

W.D. Gay

Pennsylvania Unpatented
Claim Drill Holes with
Intercepts
Yarnell Project
Yavapai County, AZ

Per your request I have tabulated the drill holes with intercepts which lie within the Pennsylvania Unpatented Lode Claim.

| Hole No. YM- | Intercept (opt Au) |
|---|---|
| 10 | 190-225 (35') @ .029 |
| 11 | 175-240 (65') @ .049 |
| 22 | 270-285 (15') @ .025 |
| 23 | 40-125 (85') @ .047 |
| 29 | 220-230 (10') @ .033 |
| 46 | 200-260 (60') @ .012 |
| 47 | 170-205 (35') @ .031 |
| 49 | 140-160 (40') @ .049 |
| 51 | 165-170 (5') @ .061 |
| 75 | 105-160 (65') @ .066 |

MAM:mek

Mark A. Miller
Project Geologist

cc: J.D. Sell

JDS

**ASARCO**

**Southwestern Exploration Division**

June 15, 1990

M.A. Miller

Assay Sheets - Reports
Yarnell Area
Yavapai County, Arizona

I have a number of assay sheets, but am unable to attach them to a report. I may have missed some, but keep me corrected by listing the reports and dates.

| Assay Sheet/Code | Report/To | Date |
|---|---|---|
| 8/3/89, Triad, RH-Series | | |
| 8/7/89, Triad, PA- & Y-Series | | |
| 11/15/89, Triad, YAR & Y-Series | | |
| 12/22/89, Triad, Y-, B-, WEL, etc. | | |
| 1/4/90, Triad, Y-Series | | |
| 1/13/90, Triad, Y-Series | | |
| 1/23/90, Triad, Y- & L-Series | | |
| 2/19/90, Triad, OCT-1 | | |
| 3/20/90, Triad, Y-Series | | |

James D. Sell

JDS:mek

James D. Sell

cc: W.L. Kurtz

**ASARCO**

**Southwestern Exploration Division**

June 15, 1990

J.D. Sell

Yarnell Project
Slides of Core Holes
YDDH-1 - YDDH-4

During January 1990, I spent several days photographing the Yarnell Core Holes YDDH-1 thru YDDH-4. Each core box was individually photographed which included a tag indicating the hole number, box number, and intervals.

Photographing was done with a Sears 35mm camera, focal length 48mm. Both Kodak and Fuji ASA 100 slide film was used. The camera was set on a tripod and adjusted so that the shutter speed was 1/125, and the F setting was F-8. The core was wet down with a fine mist before photographing to enhance color.

All the slides were then viewed and placed in order into a carousel slide tray with 140 slots. They are presently being stored in M.A. Miller's office and may be viewed ~~with his permission.~~ should be in ASARCO slide collection.

John J. Malusa

JJM:mek

John J. Malusa

cc: W.L. Kurtz
M.A. Miller

JDS

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

June 15, 1990

Mr. M.D. Philpot
Norgold Resources, Inc.
Suite 206/210
475 Howe Street
Vancouver, BC V6C 2B3
Canada

Yarnell Land Status

Dear Mr. Philpot:

As you have requested I submit a preliminary map showing the location of the Norgold-Asarco land position (attached).

We are unable to verify your State Lease 08-96981 to contain the remainder of Section 22, T10N, R5W, but we are aware that a mining claim covers the area of the "View Point" and apparently preceded the State Lease.

Note also the "Albright" area in Section 15, in which the surface and minerals belong to Albright in fee, same with "Grantham" in Section 14.

The "C. Olsen" claim(s) are held by C. Olsen, recently deceased, in Section 23.

Norgold has a First Right-of-Refusal on the Layton claims in Section 23.

A variable right-of-way is held by the Arizona Department of Transportation along both the abandoned part of highway 89, and the new double segment of highway 89.

#6849

On the large map, attached, you will note the "Hayes, Grantham, and Breshears" areas in Section 15, these are surface ownerships, with Asarco YAR-mineral claims covering those portions indicated.

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

On the south end in YAR-29 and YAR-30, adverse portions of older claims held by Laytons also occur, but Asarco has not been able to verify their positions, but may ultimately exclude some 20-30 acres of area.

Internal road right-of-ways exist along the Yarnell-Stanton county road in Section 14, and along the road to the relay towers on Yarnell Hill (Section 14), along the roads to various claims in Section 14 and 23, and the road to the newly erected radio tower on the edge of Sections 22-23, with the tower on the northeast quarter of State Lease Section 22.

Not shown is the adverse claim of D. Jenkins in the southeast quarter of Section 15.

Several power lines and telephone lines cross the area and have right-of-way passage.

Table 1 lists the claims and approximate acreage for the groups.

Sincerely,

James D. Sell

James D. Sell

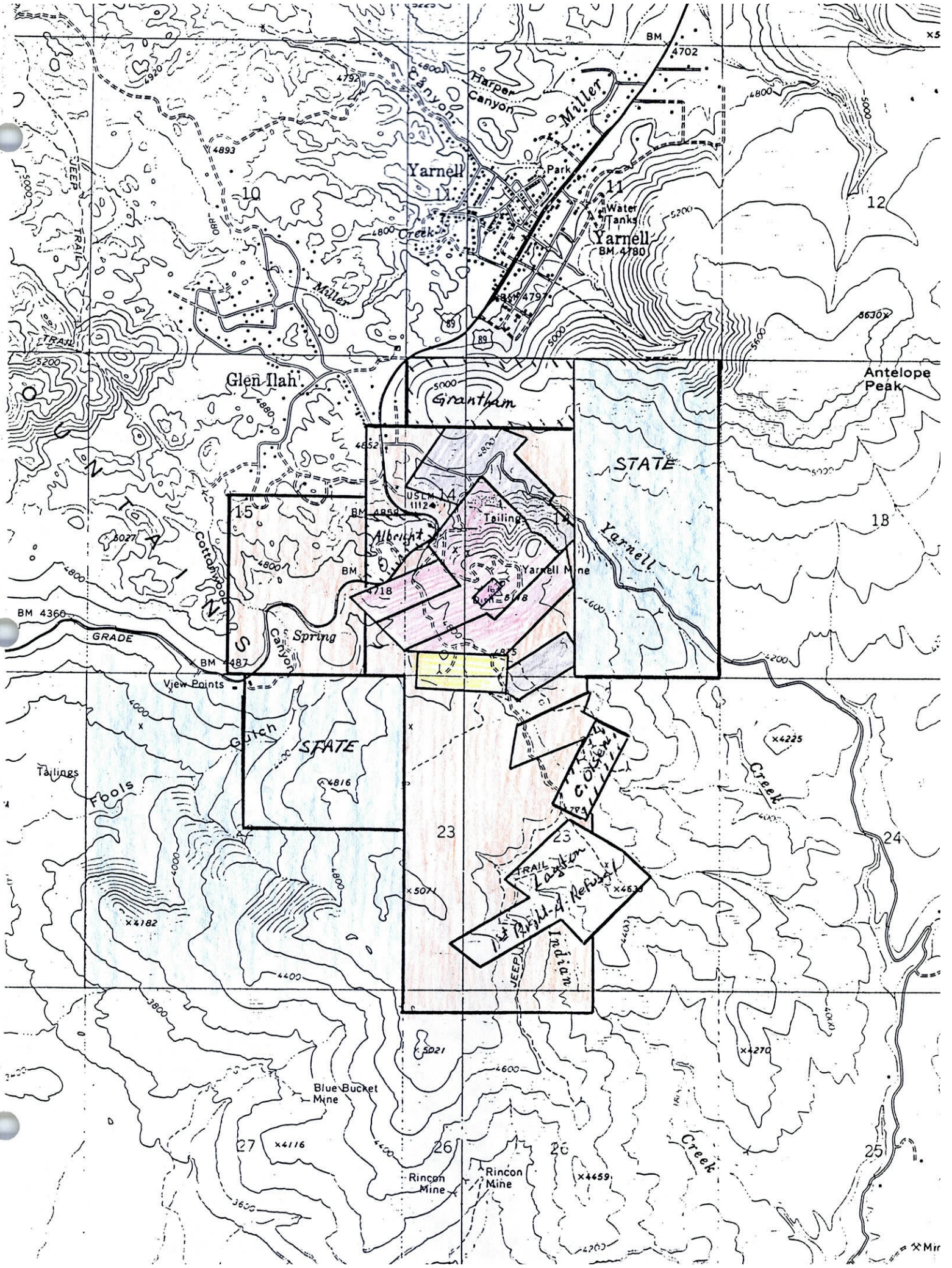
JDS:mek
Att.

cc: W.L. Kurtz
W.D. Gay
S.L. Lakosky

Table 1 - Yarnell claims and land ownership
(compiled by W.D. Gay)

The acreage is rounded to nearest acre. The ADOT and claim overlap is removed where applicable.

| PATENTED CLAIMS | ACRES |
|---|---|
| A. Norgold (Western Bldg. & Mining) Edgar, Edmond, Triangle, Juniper | 75 |
| B. Asarco/Norgold (Heintzelman) Mother | 20 |
| **UNPATENTED CLAIMS** | |
| A. Asarco/Norgold YAR-1 thru 43 (YAR-40 not staked) | 430 |
| B. Norgold (Layton) Rimrock 1, Victoria's 1,2,3,4, and 5, Black Dike 1, Thunder Hill, and BDE-5 | 156 |
| C. Norgold (Layton) Katchina Doll (A State claim on State Lease E½, Sec. 14) | 20 |
| D. Asarco BD-3 | 19 |
| E. Norgold (Western Bldg. & Mining) Alvin J, Kathryn A, Kathryn B and Pennsylvania | 50 |
| F. Norgold First Right of Refusal (Layton) BDE 1,2,3, and 4 | 78 |
| **STATE LEASES - NORGOLD** | |
| A. Prospecting Permit No. 08-96868 E½, Sec. 14, T10N, R5W | 268.25 |
| B. Prospecting Permit No. 08-96869 NE¼, Sec. 22, T10N, R5W | 154.74 |
| C. Prospecting Permit No. 08-96981 balance of Sec. 22, T10N, R5W | 468.25 |
| **MISCELLANEOUS** | |
| A. Santa Fe (Microwave) | 1.7 |
| B. Maricopa County (Microwave) | 0.1 |
| **TOTAL** | 1,741 Acres |


Harper Canyon
Miller Canyon
Yarnell
Park
Water Tanks
Yarnell
BM 4780
Miller Creek
Glen Ilah
Grantham
Antelope Peak
STATE
Tailings
Yarnell Mine
Yarnell
Albright
Cottonwood Canyon
Spring Canyon
GRADE
View Points
Gulch
STATE
Tailings
Fools
Creek
Laughlin
Albright-A-Refusal
Indian
Blue Bucket Mine
Rincon Mine
Rincon Mine
Creek
JEEP TRAIL
TRAIL
JEEP
10
11
12
14
15
18
23
24
25
26
27

6/4/90

JDS
Bill Gay left this for your approval before typing.
Mary

ACRES
BDEs

| | |
|---|---|
| BDE-1 | 19.7±Ac |
| BDE-2 | 21.2 * |
| BDE-3 | 20.5 |
| BDE-4 | 16.6 |
| TOTAL = | 78.0 ACRES |

* OVERSIZE (20.66 Acres Max. size)

June 4, 1990

J.D. Sell

Yarnell Land

The following is a breakdown of claims, state leases, etc at the Yarnell Project area; ~~roads~~, right-of-way, claim overlaps removed from ~~area~~ some claims, acreage is rounded to nearest acre.

PATENTED CLAIMS

| Owner / Claims | Acres |
|---|---|
| Western Building and Mining | |
| Edgar, Edmond, Triangle and Juniper | 75 |
| ASARCO / Norgold | |
| Mother | 20 |

UNPATENTED CLAIMS

| Owner / Claims | |
|---|---|
| ASARCO / Norgold | |
| YAR-1 thru 43 (YAR-40 not staked) | 430 |
| Layton | |
| Rimrock 1, Victoria's 1, 2, 3, 4 and 5, Black Dike 1, Thunder Hill and BDF-5. | 156 |
| Katchina Doll (State Claim) (in State lease area) E½ Sec. 14 of | 20 |
| ASARCO | |
| BD-3 | 19 |
| Western Building and Mining | |
| Alvin J, Pennsylvania, Kathryn A and Kathryn B. | 50 |

## State Leases

| | Acres ± |
|---|---|
| Prospecting Permit No 08-96868<br>E½ Section 14, T10N, R5W | 268.25 |
| Prospecting Permit No 08-96869<br>NE¼ Section 22, T10N, R5W | 154.74 |

## Miscellaneous

| | |
|---|---|
| Santa Fe (Microwave) | 1.7 |
| Maricopa County (Microwave) | .1 |
| ~~[illegible]~~ total | |

Norgold 1st right of refusal with Lessee on BDE 1, 2, 3 & 4.

approximately ~~potential~~ total

Note: Gran et also in the 1st right of refusal with Lessee ~~probably would~~ are partially within YAR-29 and YAR-30, but true location ~~cannot be verified~~ has not been ~~[illegible]~~ determined.

Say all right of ways.
Say something about radio towers & its right of way
Say something about adjacent & any other adverse ownership

**ASARCO**

**Southwestern Exploration Division**

June 18, 1990

W.D. Gay

Drill Costs
Pennsylvania Unpatented Claim
Yarnell Project
Yavapai County, Arizona

Per your request I have tabulated drill costs for the Pennsylvania Unpatented claim.

| Hole # | T.D. | Drill Costs | Assay Costs | Total |
|---|---|---|---|---|
| YM-10 | 300' | $4,603.00 | $630.00 | $5,233.00 |
| YM-11 | 260' | 2,257.00 | 560.00 | 2,817.00 |
| YM-22 | 380' | 3,074.00 | 800.00 | 3,874.00 |
| YM-23 | 140' | 1,811.00 | 300.00 | 2,111.00 |
| YM-29 | 280' | 2,436.00 | 700.00 | 3,136.00 |
| YM-46 | 300' | 2,269.00 | 640.00 | 2,909.00 |
| YM-47 | 320' | 2,419.00 | 670.00 | 3,089.00 |
| YM-49 | 220' | 1,669.00 | 470.00 | 2,139.00 |
| YM-51 | 240' | 1,800.00 | 520.00 | 2,320.00 |
| YM-75 | 220' | 1,862.00 | 780.00 | 2,642.00 |
| Total | | | | $30,270.00 |

MAM:mek

Mark A. Miller

cc: J.D. Sell

JDS

FILE

6-18-90

Yarnell Project
Yavapai Co., AZ

From: W. D. Gay

To: J. D. Sell

Re: Patenting Penn. Claim

Contacted J. Haggard & Gordon McLain (Mineral Surveyor) on 6-15.

Will start preliminary survey Monday (6-25-90).

Will kept you ~~apprie~~ apprised of progress

W. D. G.

cc: WL Hunt

J.D.S.

LAW OFFICES OF
APKER, APKER, HAGGARD & KURTZ, P.C.
A PROFESSIONAL CORPORATION
PARK ONE
2111 EAST HIGHLAND AVENUE, SUITE 230
PHOENIX, ARIZONA 85016
AREA CODE 602 TELEPHONE 381-0085

BURTON M. APKER*
JERRY L. HAGGARD**
DAVID B. APKER***
GERRIE APKER KURTZ
JOHN R. FITZPATRICK

*ALSO ADMITTED IN WISCONSIN
**ALSO ADMITTED IN DISTRICT OF COLUMBIA AND KANSAS
***ALSO ADMITTED IN COLORADO

MAILING ADDRESS
P. O. BOX 10280
PHOENIX, ARIZONA 85064-0280

TELECOPIER
(602) 956-3457

June 18, 1990

COPY

Mr. W. D. Gay
Land Engineer
ASARCO Incorporated
P.O. Box 5747
Tucson, Arizona 85703

ASARCO Incorporated
JUN 18 1990
SW Exploration

Re: Yarnell Project

Dear Mr. Gay:

This responds to your request for guidance on the procedures to obtain a patent to the Pennsylvania mining claim in the Yarnell Project. Enclosed is an outline entitled "Order of Procedures for Lode Claim Mineral Patent Applications" which was prepared for the ASARCO Northwestern Exploration Division application for patent of the Rock Creek claims. The only changes in those procedures are marked on pages 5 and 6 of the enclosed Order of Procedures dealing with the Notice of Application for Patent being posted in the BLM State Office rather than in the District Office.

It is worth emphasizing that the BLM insists upon, and the Mining Law requires in many cases, strict compliance with these technical procedures. In the Rock Creek situation, for example, the newspaper publication of the Notice of Application had to be repeated because someone removed the Notices of Application posted on the claims and the Affidavit of Continuous Posting during the publication period could not be provided.

The most crucial element of the Patent Application will be the drilling and geologic data submitted to prove that the Pennsylvania claim contains ore in sufficient grade and quantity that the ore can be mined (in conjunction with mining the ore from the other parts of the ore body) and sold at a profit. Because the Pennsylvania claim could not likely be mined by itself, this will require submitting geologic and economic data for the entire ore body. At least some of this data is likely to be regarded as confidential and should be submitted as an appendix to the Patent

Application and each page containing confidential information should contain the following statement (stamped or typewritten somewhere on the page):

"FOR OFFICIAL USE ONLY

This information is specifically exempted from public disclosure under the Freedom of Information Act by statute and as privileged and confidential trade secrets and commercial information. Disclosure of this information is prohibited by 36 C.F.R. 228.6. Any employee of the United States who publishes, divulges, discloses or makes known this information may be subject to the criminal penalties prescribed by 18 U.S.C. 1905."

Finally, before commencing even the mineral survey process, it is advisable that you meet with Alan Rabinoff or Tom Reitmeyer in the Mineral Adjudication Branch in the BLM State Office. This meeting would be both for the courtesy of allerting that office that the Application will be filed, to discuss generally the data ASARCO has on the ore body and to learn of any problems the BLM may anticipate with the Application. For example, it may be necessary to conduct additional drilling, or the BLM may be so adamant that the claim is not patentable that ASARCO should make the early decision whether to hold the claim as unpatented or be prepared to prove through any appeals if necessary that the claim is patentable.

As you proceed, please feel free to contact us with any questions you may have or to prepare any of the forms of the enclosed samples which you will need.

Sincerely,

Jerry

Jerry L. Haggard
For APKER, APKER, HAGGARD & KURTZ, P.C.

JLH/jb
Enclosures

cc: James L. Woods, Esq.

* Called Reitmeyer - he said to commence the process. i.e. a meeting was not needed.

W.W.G.

✓ copy FT Craybeal

JDS — "green" sericite not uncommon around ~~mon~~ and in many gold deposits in Montana and Alaska.

**ASARCO**

Southwestern Exploration Division

w/o attachments to the Malusa Rpt

June 20, 1990

W.L. Kurtz

I supposed it would be appropriate to put conclusions first and the start of report

J.J. Malusa's Report
Green Mineral
Yarnell Footwall Core
Yarnell Project
Yavapai County, Arizona

Lastly. He writes very well.

I submit J.J. Malusa's report on the green mineral in the footwall from drill hole YDDH-1, 320 feet.

As John has deduced, the green mineral is dominantly sericite made up of fine-grained muscovite/illite, but the XRD work did not suggest what was causing the green coloration.

"Green sericite" has commonly been logged in the more central parts of the hydrothermal porphyry copper systems, and may be a result of the high-heat flow as expressed by Malusa.

The YAR-15 discovery site is 1500 feet south of the Yarnell fault, and, based on projecting the fault at 30°, would place the pit sample 600 feet into the footwall granite.

James D. Sell

James D. Sell

JDS:mek
Att.

cc: M.A. Miller
J.J. Malusa

**ASARCO**

**Southwestern Exploration Division**

JDS

June 20, 1990

W.L. Kurtz

J.J. Malusa's Report
Green Mineral
Yarnell Footwall Core
Yarnell Project
Yavapai County, Arizona

I submit J.J. Malusa's report on the green mineral in the footwall from drill hole YDDH-1, 320 feet.

As John has deduced, the green mineral is dominantly sericite made up of fine-grained muscovite/illite, but the XRD work did not suggest what was causing the green coloration.

"Green sericite" has commonly been logged in the more central parts of the hydrothermal porphyry copper systems, and may be a result of the high-heat flow as expressed by Malusa.

The YAR-15 discovery site is 1500 feet south of the Yarnell fault, and, based on projecting the fault at 30°, would place the pit sample 600 feet into the footwall granite.

James D. Sell

James D. Sell

JDS:mek
Att.

cc: M.A. Miller
J.J. Malusa

**ASARCO**

**Southwestern Exploration Division**

JDS

June 19, 1990

J.D. Sell

Green Mineral
Yarnell Footwall Core
Yarnell Project
Yavapai County, Arizona

Here is the work on the footwall "green core." The bill for the XRD work is still in the making, so I didn't include the study cost. The whole rock analysis will be written up separately because it didn't really help out much as far as identifying the cause of the green coloration.

John J. Malusa

JJM:mek

cc: W.L. Kurtz

**ASARCO** Southwestern Exploration Division

June 19, 1990

J.D. Sell

Green Mineral
Yarnell Footwall Core
Yarnell Project
Yavapai County, Arizona

As you have instructed, I have determined the mineral or element causing a pale green cast in many of the crystals/grains in the core intervals that are within the immediate footwall at Yarnell. Through the use of two methods: 1) X-ray diffraction and 2) optical mineralogy, it was possible to do this.

The following report will be organized so that the results and conclusions from the two methods will be presented separately and then a conclusion regarding both methods and field observations will follow. All the following XRD and thin section work was done from core sample YDDH-1 320'.

X-Ray Diffraction Discussion

The sample tested was obtained from the core by etching out a green crystal/grain with an engraving tool. This method was used in order to retrieve the green material without contaminating it with "non-green" material.

The machine used was the UofA's Siemens D-500 X-ray diffractometer. Specifications are as follows: mA 30, KV 40, Target Cu, Scan 2°2O/min, chart speed 2 cm/min linear, 1 second time const., Scint. 964V counter tube, graphite monochrometer filter, 1° beam slit, 0.15° detector slit, 1 x $10^3$ imp./sec full scale measuring range.

Results from the X-ray diffraction are located in Attachments 1 and 2. Attachment 1 contains the diffraction pattern while Attachment 2 contains computer generated diffraction data. The computer data contains 4 categories of information:

1) A list of 2 - theta's (degrees) derived from the diffraction pattern.

2) A list of d - spacing (A) derived from the diffraction pattern.

3) A list of minerals that best fit the diffraction pattern. These

are listed so that the first one of the list is the most likely/abundant mineral and the last one is the least likely/abundant.

4) Listing of suspected minerals and their d - spacing (A).

To help guide you through the computer data sheet, I have numbered and highlighted the 4 categories on the printout.

## Interpretation

With the aid of thin section comparison observations, one can conclude that the green material consists mainly of sericite and some remnant plagioclase. These observations are consistent with the XRD computer interpretation of the best fit minerals (category #3, omitting the minerals below illite trioctahedral in the list). The muscovite/illite species and taeniolite are all phyllosilicates that together make up the sericite composition. The low albite (a slow cooled well ordered crystal latice form of albite) exists due to the sericite not completely altering the plagioclase.

The presence of taeniolite ($KLiMg_2Si_4O_{10}F_2$) is interesting due to it being present in both the Yarnell Fault Gouge and the sericite in the footwall core. XRD data and computer interpretation showed taeniolite being the best fit mineral (or one of the most abundant) for the fault gouge and the second best fit for the footwall core. This leads one to believe that there is a substantial quantity of taeniolite in the system. Unfortunately, taeniolite is optically indistinguishable from fine grained muscovite; therefore, we only know it's there from the XRD work, but not how abundant.

## Thin Section Discussion

Thin section observations of solely the green grains revealed them to consist of 98% sericite and 2% plagioclase. In some areas of intense sericitization it appears that recrystallization of the sericite has formed secondary muscovite. In Honea's Report (March 14, 1990) he reports muscovite in two places that are near the Yarnell Fault (Y-167, Y-168). After observing the green core thin section and Honea's photomicrographs, I feel that the muscovite Honea reported is recrystallized sericite and not a deuteric mineral.

Thin sections not only provided the final confirmation of the sericitic composition of the green grains, but also revealed valuable information pertaining to the rock genesis. In thin section, the characteristics

and relationships of minerals provide evidence for fracturing prior to alteration. The fracturing event is detected by the shattered microcline crystals. Their original crystal shape is still detectable; however, pervasive fracturing is seen in all the microcline observed. Secondly, deformation is detectable by the presence of partially deformed plagioclase pseudomorphs.

Four lines of evidence for alteration post deformation are presented:

1) Quartz crystals exhibit many triple junctions at the interphase with other quartz crystals. This characteristic is indicative of a high heat flow with subsequent melting, and recrystallization with little stress and strain during the recrystallization.

2) Quartz crystals exhibit only minor undulatory extinction which is indicative of little stress and strain while recrystallizing. However, some crystals show moderately undulatory extinction, inferring some stress did occur after recrystallization, but not at the magnitude that initially pervasively shattered the rock.

3) Sericite crystals (i.e., fine grained muscovite and taeniolite) would show a foliation if they were exposed to shearing due to their micaceous character allowing for easy slippage and crystal alignment. The sericite observed displayed no preferred orientation; therefore, the sericite was not exposed to shearing.

4) The plagioclase pseudomorphs are still detectable after being almost fully altered to sericite. If shearing occurred after alteration, the plagioclase pseudomorphs would be destroyed.

These four lines of evidence make it possible to infer that a deformation event of substantial magnitude (seen in shattered microcline and partially deformed plagioclase pseudomorphs) predated the alteration event.

## Silicification

The high competence of the rock (personally observed while sawing the core) is due to both the free silica produced during sericitization and the high heat flow allowing for the silica to remobilize and recrystallize in voids caused by shattering. This in turn "heals" the rock from the deformation event and even makes the altered granite more competent than the unaltered granite. In thin section this is seen by the abundance of quartz and the fact that quartz usually fully encircles grains of sericite or microcline.

Green Mineral
Yarnell Footwall Core

June 19, 1990

Thin Section Observations

Green Core -> moderately shattered sericitized and silicified.

| Primary Minerals | Percent | Description |
|---|---|---|
| Plagioclase | 2 | Subhedral to anhedral, albite twinning, almost completely replaced by sericite. |
| Microcline | 25 | Subhedral to Anhedral, grid twinned, grains moderately crushed and are generally unaltered. |
| Quartz | 30 | Fine to medium grain, anhedral, granular mosaic with dominantly triple junction contacts. Many grains have moderately undulatory extinction, present in aggregates interstitial to feldspars/sericite. |
| Varietal Accessory Minerals | | |
| Biotite | <1 | Almost completely altered to sericite and opaques. |
| Minor Accessory Minerals | | |
| Zircon | <1 | Extreme positive relief, high birefringence. |
| Rutile | <1 | Tiny needle-like crystally with extreme positive relief, present as inclusion in quartz. |
| Apatite | <1 | Small colorless prisms with moderate positive relief and high birefringence,enclosed by quartz. |

Green Mineral
Yarnell Footwall Core

June 19, 1990

| Secondary Minerals | Percent | Description |
|---|---|---|
| Sericite | 35 | Very fine to medium grain. Subhedral to anhedral, occurs mostly in aggregates replacing plagioclase, but also as complete replacement of biotite and in small fractures that cut quartz and microcline. |
| Chlorite | <1 | Fine grained, subhedral, light green to green pleochroism occurs as fracture filling. |
| Magnesite | <1 | Fiberous, subhedral, highly pleochroic, inclined extinction, fracture filling associated with chlorite. |
| Muscovite | <1 | Subhedral recrystallized sericite, associated with sericite replacing plagioclase. |
| Fe/Ti oxides | 3 | Euhedral to anhedral opaque masses associated with alteration of biotite and magnetite. |

Texture: Originally coarse grained phaneritic, equigranular. Is now highly sericitic and silicified.

## Conclusion

The objective of this work (identify the green color in footwall core) was reached through the combination of XRD and optical mineralogy. Without a doubt, the green grains are a result of extensive sericitization of the plagioclase and not chlorite as suspected from hand sample observation techniques.

The green coloration of the sericite is probably the result of phengite which is commonly associated with hydrothermal solutions rich in silica. Chemically, phengite is a muscovite with a disproportional amount of either Si, Fe, or Mn substituting in the Al site. Thin sections and XRD cannot distinguish it from "regular muscovite" chemistry.

Not surprisingly, other "bonus information" regarding the chemistry and rock genesis of Yarnell was also obtained through this work.

With regard to the rock genesis, thin section work furnished substantial evidence that at least one significant deformation event preceded the alteration event with no substantial deformation after the alteration event.

Insight about chemical constituents involved in the alteration event was gained through XRD. Mainly the discovery of the Li and F bearing phyllosilicate taeniolite in the sericite and fault gouge. Li bearing minerals such as taeniolite are somewhat rare, commonly associated with a pegmatitic environment (i.e., hydrothermal solution enriched in volatiles) and other Li bearing minerals such as tourmaline. Honea does report seeing trace tourmaline in a few of his thin sections; however, he doesn't consider them a secondary mineral.

Tourmaline associated with quartz veins and X-large feldspars occur at several locations near the Yarnell Ore Deposit, in particular at the claim discovery for YAR 15 which assayed at .144 opt. Although it is only circumstantial evidence, I would propose that structures genetically related to the ore on YAR 15 are responsible for the alteration/gold mineralization at Yarnell.

John J. Malusa

JJM:mek

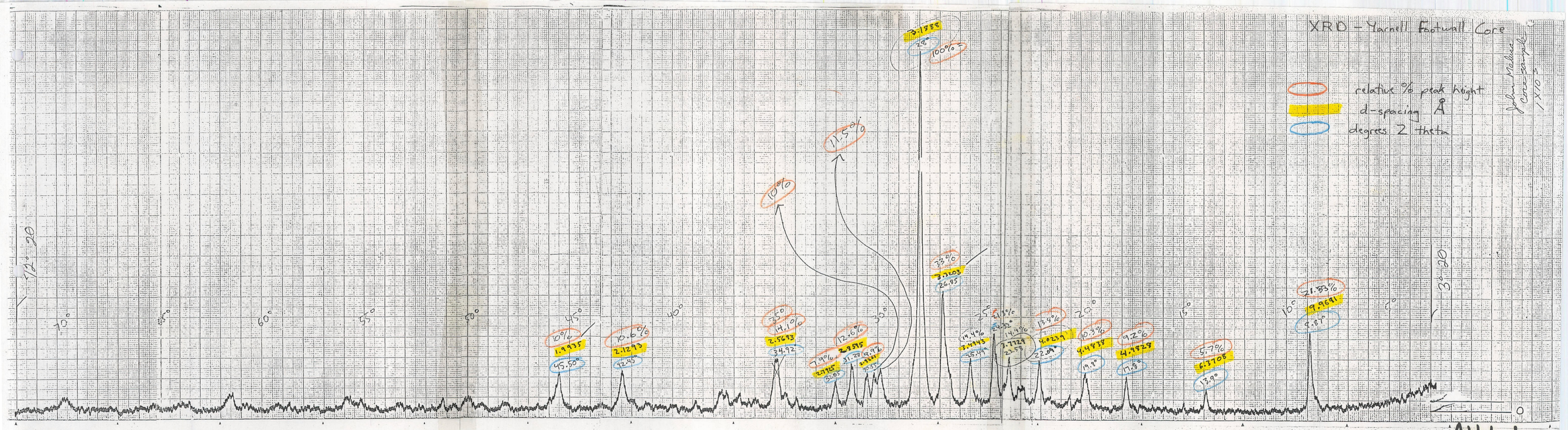
cc: W.L. Kurtz

Attch 2

```
H       ** OBSERVED PATTERN DISPLAY ** #1

 DISPLAY DATA AS 2-THETA OR D [D:D] > 2-THETA
ENTER ELEMENT SYMBOL FOR RADIATION [D:CU]>
2J H            CORE
 1    8.870   22
 2   13.900    6
 3   17.800    9
 4   19.800   10
 5   22.090   14
 6   23.580   15
 7   24.320   21
 8   25.490   14
 9   26.850   33
10   28.000  100
11   29.900   12
12   30.180   10
13   30.550   10
14   30.551    0
15   31.280   13
16   32.050    8
17   34.920   14
18   42.450   11
19   45.500   10
ENTER RETURN TO CONTINUE >

 ENTER OPTION # OR RETURN FOR MAIN MENU > 1
2J H       ** OBSERVED PATTERN DISPLAY **
                                        #2
 DISPLAY DATA AS 2-THETA OR D [D:D] > D-spacing
2J H            CORE
 1    9.969   22
 2    6.371    6
 3    4.983    9
 4    4.484   10
 5    4.024   14
 6    3.773   15
 7    3.660   21
 8    3.494   14
 9    3.320   33
10    3.187  100
11    2.988   12
12    2.961   10
13    2.926   10
14    2.926    0
15    2.860   13
16    2.793    8
17    2.569   14
18    2.129   11
19    1.994   10
ENTER RETURN TO CONTINUE >
```


XRD - Yarnell Footwall Core
relative % peak height
d-spacing Å
degrees 2 theta
John Malone
Core sample
/XRD 5
1/2° 2θ
3° 2θ
70°
65°
60°
55°
50°
45°
40°
35°
30°
25°
20°
15°
10°
5°
0
10%
1.9935
45.50°
10.60%
2.1293
42.45°
10%
3.60
14.10%
2.5613
34.92
7.90%
2.7815
32.05°
12.60%
2.9595
31.29
9.90%
3.0161
30.55°
11.50%
3.1888
28°
100%
3
33%
3.2203
26.95
14.90%
3.4943
25.49°
14.90%
3.7729
23.55°
13.90%
4.0239
22.09°
10.30%
4.4838
19.8°
9.20%
4.9829
17.8°
5.70%
6.3708
13.9°
21.53%
9.9691
8.8°

Attch. 1

#3

Best fit Mineral List

```
 ENTER OPTION # >5
2J H    **  SEARCH/MATCH **
2J H    CORE                          NUMBER OF MATCHED CARDS:     14
                    NAME                    PDF NO.        FOM
          MUSCOVITE 2MO                      6- 263         2
          TAENIOLITE 1                      31-1045         7
          ALBITE  LOW                        9- 466         7
          MUSCOVITE 3T                       7-  42         8
          MUSCOVITE  2M2                    34- 175         8
          ALBITE  LOW                       20- 554         9
          MUSCOVITE 2MO  VANADI             19- 814        10
          ILLITE 2MO                        26- 911        12
          ILLITE  TRIOCTAHEDRAL              9- 343        25
          EUXENITE  HEATED                   9- 442        29
          TADZHIKITE                        24- 137        31
          SCHORL                            22- 469        32
          WODGINITE                         29- 901        43
          WEGSCHEIDERITE                    15- 653        51

DISPLAY CARDS? Y/N [D:N] >
```

#4

Suspected Minerals and their d-spacing

```
2J H DISPLAY DATA AS D OR 2-THETA [D:D] > D
2J H  9  466     NA AL SI3 O8                          I/IC=    .00     QM= *
             ALBITE  LOW
 1    6.393   20     21    2.538    2
 2    5.941    2     22    2.512    2
 3    5.590    2     23    2.496    6
 4    4.032   16     24    2.460    6
 5    3.857    8     25    2.444    4
 6    3.781   25     26    2.431    2
 7    3.685   20     27    2.405    2
 8    3.664   16     28    2.388    4
 9    3.509   10     29    2.320    4
10    3.485    2     30    2.278    2
11    3.376    8     31    2.189    4
12    3.196  100     32    2.125    8
13    3.151   10     33    2.119    6
14    2.965   10     34    2.076    2
15    2.933   16     35    2.035    2
16    2.866    8     36    2.000    2
17    2.843    2     37    1.980    4
18    2.788    2     38    1.927    2
19    2.639    6     39    1.889    8
20    2.563    8
```

ENTER RETURN TO CONTINUE; R TO REDISPLAY > *

2J H DISPLAY DATA AS D OR 2-THETA [D:D] > D

2J H 34 175 ( K NA )0 .8 ( SI AL )6 O11 ( O H I/IC= .36 QM= *

MUSCOVITE 2M2

| | | | | | |
|---|---|---|---|---|---|
| 1 | 9.984 | 100 | 21 | 2.555 | 89 |
| 2 | 4.990 | 26 | 22 | 2.512 | 5 |
| 3 | 4.445 | 71 | 23 | 2.495 | 4 |
| 4 | 4.337 | 19 | 24 | 2.438 | 34 |
| 5 | 4.271 | 32 | 25 | 2.413 | 28 |
| 6 | 3.938 | 2 | 26 | 2.384 | 33 |
| 7 | 3.879 | 39 | 27 | 2.328 | 2 |
| 8 | 3.781 | 3 | 28 | 2.297 | 6 |
| 9 | 3.655 | 75 | 29 | 2.266 | 6 |
| 10 | 3.556 | 2 | 30 | 2.241 | 20 |
| 11 | 3.493 | 83 | 31 | 2.231 | 16 |
| 12 | 3.328 | 46 | 32 | 2.205 | 10 |
| 13 | 3.182 | 80 | 33 | 2.195 | 10 |
| 14 | 3.125 | 9 | 34 | 2.178 | 9 |
| 15 | 3.036 | 72 | 35 | 2.171 | 11 |
| 16 | 2.929 | 22 | 36 | 2.138 | 7 |
| 17 | 2.846 | 47 | 37 | 2.076 | 37 |
| 18 | 2.795 | 51 | 38 | 2.065 | 30 |
| 19 | 2.577 | 69 | 39 | 2.058 | 6 |
| 20 | 2.567 | 86 | 40 | 2.042 | 24 |

ENTER RETURN TO CONTINUE; R TO REDISPLAY >

2J H DISPLAY DATA AS D OR 2-THETA [D:D] > D

2J H 19 814 K ( AL, V )2 ( SI, AL )4 O10 ( O H I/IC= .00 QM= I

MUSCOVITE 2

| | | | | | |
|---|---|---|---|---|---|
| 1 | 9.973 | 90 | 21 | 2.128 | 30 |
| 2 | 4.990 | 20 | 22 | 1.994 | 40 |
| 3 | 4.480 | 80 | 23 | 1.733 | 10 |
| 4 | 4.292 | 20 | 24 | 1.668 | 10 |
| 5 | 4.132 | 50 | 25 | 1.647 | 80 |
| 6 | 3.880 | 50 | 26 | 1.602 | 10 |
| 7 | 3.740 | 50 | 27 | 1.524 | 10 |
| 8 | 3.490 | 60 | 28 | 1.504 | 90 |
| 9 | 3.341 | 90 | 29 | 1.247 | 20 |
| 10 | 3.201 | 60 | | | |
| 11 | 2.991 | 60 | | | |
| 12 | 2.862 | 30 | | | |
| 13 | 2.791 | 30 | | | |
| 14 | 2.602 | 20 | | | |
| 15 | 2.569 | 100 | | | |
| 16 | 2.493 | 10 | | | |
| 17 | 2.395 | 30 | | | |
| 18 | 2.251 | 20 | | | |
| 19 | 2.209 | 10 | | | |
| 20 | 2.151 | 30 | | | |

ENTER RETURN TO CONTINUE; R TO REDISPLAY >

```
 OR SKIP FOR NEXT CARD

2J H DISPLAY DATA AS D OR 2-THETA [D:D] ) D
2J H 26  911     ( K, H3 O ) AL2 SI3 AL O10 ( O H )     I/IC=    .00     QM= I
            ILLITE 2MO
 1   10.006  90
 2    5.021  50
 3    4.480  16
 4    4.440  14
 5    3.890   8
 6    3.720  12
 7    3.461  14
 8    3.341 100
 9    3.201  16
10    2.989  18
11    2.867  12
12    2.800  12
13    2.558  12
14    2.510   8
15    2.463   8
16    2.241   4
17    2.005  50
18    1.499  14

 ENTER RETURN TO CONTINUE; R TO REDISPLAY )



 PRESS RETURN WHEN READY
  OR TYPE END TO ABORT
  OR SKIP FOR NEXT CARD

2J H DISPLAY DATA AS D OR 2-THETA [D:D] ) D
2J H  9  343     K ( AL, MG )3 SI3 AL O10 ( O H )2     I/IC=    .00     QM= I
            ILLITE  TRIOCTAHEDR
 1   10.006 100
 2    4.951  20
 3    4.480  90
 4    3.691  20
 5    3.331  90
 6    3.171   5
 7    2.871  10
 8    2.610  60
 9    2.510  10
10    2.420  40
11    2.160  20
12    1.986  10
13    1.667  30
14    1.530  60
15    1.449   5
16    1.323   5

 ENTER RETURN TO CONTINUE; R TO REDISPLAY )
```

```
2J H DISPLAY DATA AS D OR 2-THETA [D:D] > D
2J H  9  442     ( Y, CE ) ( NB, TI )2 06                I/IC=    .00     QM= I
```

EUXENITE HEATED

| | | | | | |
|---|---|---|---|---|---|
| 1 | 7.285 | 16 | 21 | 1.941 | 14 |
| 2 | 3.661 | 40 | 22 | 1.897 | 25 |
| 3 | 3.371 | 20 | 23 | 1.880 | 4 |
| 4 | 3.281 | 10 | 24 | 1.830 | 30 |
| 5 | 2.991 | 100 | 25 | 1.806 | 20 |
| 6 | 2.950 | 40 | 26 | 1.774 | 25 |
| 7 | 2.780 | 25 | 27 | 1.731 | 25 |
| 8 | 2.630 | 10 | 28 | 1.727 | 30 |
| 9 | 2.601 | 30 | 29 | 1.704 | 4 |
| 10 | 2.550 | 20 | 30 | 1.683 | 4 |
| 11 | 2.521 | 6 | 31 | 1.643 | 25 |
| 12 | 2.450 | 16 | 32 | 1.625 | 6 |
| 13 | 2.430 | 20 | 33 | 1.614 | 10 |
| 14 | 2.310 | 18 | 34 | 1.590 | 12 |
| 15 | 2.210 | 14 | 35 | 1.565 | 16 |
| 16 | 2.190 | 14 | 36 | 1.540 | 16 |
| 17 | 2.120 | 20 | 37 | 1.505 | 10 |
| 18 | 2.080 | 4 | 38 | 1.496 | 16 |
| 19 | 2.040 | 6 | 39 | 1.492 | 25 |
| 20 | 1.979 | 10 | 40 | 1.476 | 6 |

```
ENTER RETURN TO CONTINUE; R TO REDISPLAY >
```

```
DISPLAY DATA AS D OR 2-THETA [D:D] > D
2J H  9  442     ( Y, ER ) ( NB, TA, TI ) 04             I/IC=    .00     QM=
```

FERGUSONITE HEATED

| | | | | | |
|---|---|---|---|---|---|
| 1 | 5.470 | 4 | 21 | 1.627 | 16 |
| 2 | 4.581 | 4 | 22 | 1.620 | 16 |
| 3 | 4.021 | 4 | 23 | 1.569 | 10 |
| 4 | 3.290 | 4 | 24 | 1.563 | 16 |
| 5 | 3.121 | 100 | 25 | 1.559 | 10 |
| 6 | 3.011 | 20 | 26 | 1.508 | 6 |
| 7 | 2.961 | 90 | 27 | 1.504 | 6 |
| 8 | 2.740 | 40 | 28 | 1.500 | 6 |
| 9 | 2.641 | 20 | 29 | 1.478 | 4 |
| 10 | 2.590 | 4 | 30 | 1.369 | 4 |
| 11 | 2.530 | 10 | 31 | 1.321 | 4 |
| 12 | 2.521 | 10 | 32 | 1.288 | 2 |
| 13 | 2.220 | 4 | 33 | 1.263 | 2 |
| 14 | 2.160 | 6 | 34 | 1.245 | 2 |
| 15 | 2.010 | 6 | 35 | 1.236 | 4 |
| 16 | 1.901 | 50 | 36 | 1.213 | 4 |
| 17 | 1.855 | 30 | 37 | 1.189 | 4 |
| 18 | 1.754 | 10 | 38 | 1.146 | 4 |
| 19 | 1.646 | 10 | 39 | 1.107 | 4 |
| 20 | 1.643 | 10 | 40 | 1.088 | 4 |

```
ENTER RETURN TO CONTINUE; R TO REDISPLAY >
```

VDS

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

REPORT OF ANALYSIS

JOB NO. TAJ 637
May 5, 1990


ASARCO INCORPORATED
Attn: Mr. John Malusa
Southwestern Exploration
P.O. Box 5747
Tucson, AZ 85703

Analysis of 1 Rock Chip Sample Green Core

| ITEM | SAMPLE NO. | SiO2 (%) | TiO2 (%) | Al2O3 (%) | Fe2O3 (%) |
|---|---|---|---|---|---|
| 1 | 1 | 68.3 | .02 | 14.3 | 3.5 |

| ITEM | SAMPLE NO. | FeO (%) | MnO (%) | MgO (%) | CaO (%) |
|---|---|---|---|---|---|
| 1 | 1 | .10 | .01 | .70 | 2.6 |

ASARCO [illegible]
MAY 8 1990
SW Exploration

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

JOB NO. TAJ 637
May 5, 1990


| ITEM | SAMPLE NO. | Na2O (%) | K2O (%) | P2O5 (%) |
|---|---|---|---|---|
| 1 | 1 | 2.0 | 5.3 | .10 |

William L. Lehmbeck
Manager

ASARCO Incorp.
MAY 8 1990
SW Exploration

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

INVOICE
NET 30 DAYS

Job No. TAJ 637
May 5, 1990

ASARCO INCORPORATED
Attn: Mr. John Malusa
Southwestern Exploration
P.O. Box 5747
Tucson, AZ 85703

Analysis of 1 Rock Chip Sample

| | |
|---|---|
| 1 $SiO_2$(%) @ $9.00 | $9.00 |
| 1 $TiO_2$(%) @ $6.10 | $6.10 |
| 1 $Al_2O_3$(%) @ $3.66* | $3.66 |
| 1 $Fe_2O_3$(%) @ $3.66* | $3.66 |
| 1 FeO(%) @ $8.50 | $8.50 |
| 1 MnO(%) @ $6.10 | $6.10 |
| 1 MgO(%) @ $3.66* | $3.66 |
| 1 CaO(%) @ $3.66* | $3.66 |
| 1 $Na_2O$(%) @ $3.66* | $3.66 |
| 1 $K_2O$(%) @ $3.66* | $3.66 |
| 1 $P_2O_5$(%) @ $6.10 | $6.10 |
| 1 sample crushed, split and pulverized @ $3.20 | $3.20 |
| Totals | $60.96 |

* Multi Element Discount

APPROVED FOR PAYMENT

By:_____
(Signature)

ASARCO Incorporated
MAY 8 1990
SW Exploration

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

**ASARCO**

**Southwestern Exploration Division**

June 20, 1990

S.L. Lakosky

Rental/Renewal
State Prospecting Permits
Yarnell Project
Yavapai County, Arizona

The Joint Venture has three prospecting permits under its control at Yarnell. They are as follows:

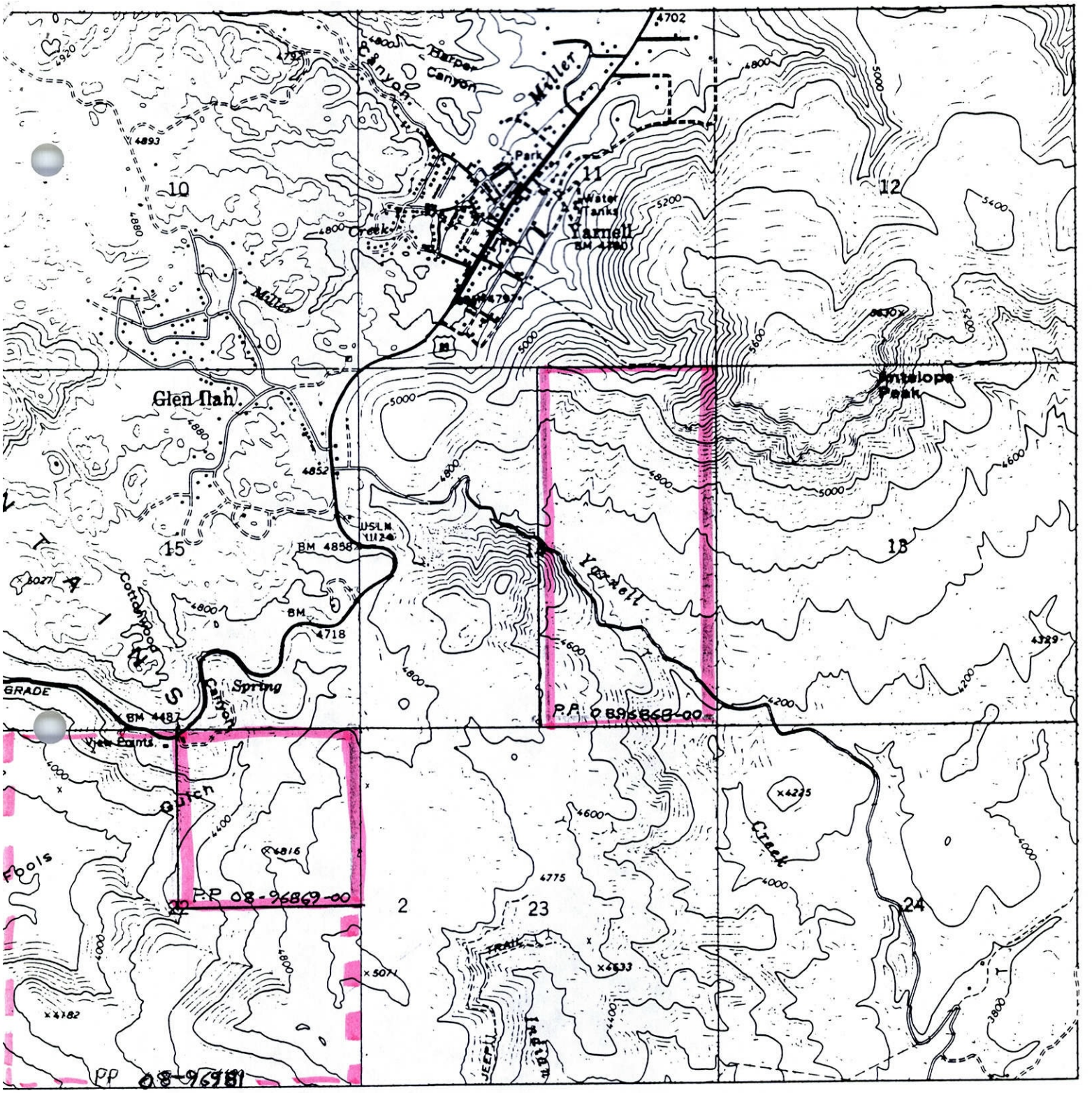
| Permit Number | Acreage | Location | Renewal Date |
|---|---|---|---|
| PP 08-96868-00 | 299.34 | E½ Sec. 14 T10N, R5W | 4/25/91 |
| PP 08-96869-00 | ≈160 | NE¼ Sec. 22 T10N, R5W | 4/25/91 |
| PP 08-96981-00 | 468.25 | Remainder Sec. 22 | 12/5/90 |

Renewal costs are $10/acre which are as exploration expenditures. This year we will need to spend $4,682.50 to satisfy renewal requirements for 96981. The other two permits are okay until April of 1991.

MAM:mek

Mark A. Miller

cc: J.D. Sell
W.L. Kurtz




1" = 2000'

YARNELL/CONGRESS
QUADS 7.5'
EXHIBIT A

# ASARCO

**Exploration Department**
Southwestern United States Division

June 20, 1990

Mr. Russ Honea
P.O. Box 323
Broomfield, Colorado 80020

Dear Russ:

The petrographic study at Yarnell has been completed. Would you please return all the sections (both thin and polished) you made. Also, we would like 35 mm color sides of all the sections you examined.

Thank you for your work in figuring out this deposit.

Respectfully,

Mark A. Miller

MAM:mek

cc: J.D. Sell

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

# ASARCO

Southwestern Mining Department
T. E. Scartaccini
General Manager

June 20, 1990

JUN 21 1990
SW Exploration

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. Forrest B. Heintzelman
1315 Cedar Crest Boulevard
Allentown, PA 18104

YARNELL PROJECT
Yavapai County, AZ

Dear Mr. Heintzelman:

Enclosed is Asarco's check for $5,000 as payment due June 30, 1990 as stated in Article 2 (b) of your Agreement and Option to Purchase with Norgold Resources (US) Inc., dated June 30, 1989.

Sincerely,

S. L. Lakosky

S. L. Lakosky
Yarnell Project Manager

SLL/kh

Encl.

cc: CMoat - Norgold Resources (US) Inc.
TEScartaccini
RLBrown
WLKurtz
JDSell
MAMiller
CLSnow

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

JDS

# NORGOLD RESOURCES INC.

U.S. OFFICES:
13935 Chamy Drive
Reno, Nevada
89511
(702) 851-3177
Fax: (702) 851-3177

HEAD OFFICE:
210 - 475 Howe Street
Vancouver, B.C.
V6C 2B3
(604) 681-5566
Fax: (604) 687-8789

June 21, 1990

Mr. James D. Sell
ASARCO Incorporated
Exploration Department
Southwestern Unites States Division
P.O. Box 5747
1150 North 7th Avenue
Tucson, Arizona
85703

Dear Jim:

Re: Mother Lode Mining Claim

Just a reminder that as per the Norgold/Heintzelman agreement at the Yarnell Project, the agreement calls for a $5,000 U.S. cash payment to Mr. Heintzelman on or before June 30, 1990. As to expedite matter, ASARCO should make this payment direct to Mr. Heintzelman c/o 1315 Cedar Crest Boulevard, Allentown, Pennsylvania, 18104.

Thank you for looking after this matter on behalf of Norgold and the project.

Sincerely,

Michael D. Philpot
President & C.E.O.

MDP/sjk

cc: S.L. Lakosky (6/21/90)

JDS

# FACSIMILE TRANSMISSION

DATE: June 21, 1990

TO: ASARCO Inc.

ATTENTION: James Dell

TOTAL NO. OF PAGES: 2 (including this page)

6/21/90

FROM: M. Phulpot.

Suite 206/210 - 475 Howe Street
Vancouver, B.C.
V6C 2B3 Canada

Telephone: (604) 681-5565

Facsimile No.: (604) 687-8789

I gave a copy to Mr Lakosky. The payment was being sent to the address as shown.

Mary

* * * * * * * * * * * * * * *

IF THIS TRANSMISSION IS NOT FULLY OR LEGIBLY RECEIVED

PLEASE TELEPHONE (604) 687-4144

OPERATOR: _____

NOTES:

original to follow via mail

cc: S.L. Lakosky (6/21/90)

# ASARCO

**Exploration Department**
Southwestern United States Division

June 20, 1990

Mr. O. Conti, President
Rhino Resources Inc.
1155 W. Georgia St.
Vancouver, B.C. V6E 3H4
Canada

Dear Mr. Conti:

Would you please send any information on your Iron Bay Group located in Yavapai County, Arizona.

Asarco is very interested in any gold prospects in Arizona that might have a bulk tonnage potential and particularly in Yavapai County. As you might be aware, we are currently developing the Yarnell property in Yavapai County, Arizona with Norgold Resources, our Joint Venture Partner. next needed.

Thank you for your time and consideration.

Respectfully,

MAM:mek

Mark A. Miller
Geologist

cc: J.D. Sell

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

# ASARCO

Southwestern Mining Department
T. E. Scartaccini
General Manager

June 20, 1990

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

ASARCO Incorp.
JUN 21 1990
SW Exploration

Mr. Christopher Moat, Chairman
NORGOLD RESOURCES (US) INC.
210-475 Howe Street
Vancouver, B.C. V6C-2B3
Canada

YARNELL PROJECT
Yavapai County, AZ

Dear Mr. Moat:

Enclosed is Asarco's check for $20,000 payment due July 1, 1990 as stated in the Asarco/Norgold Exploration and Option Agreement dated January 30, 1989.

Sincerely,

S. L. Lakosky

S. L. Lakosky
Yarnell Project Manager

SLL/kh

Encl.

cc: TEScartaccini
RLBrown
WLKurtz
JDSell[redacted]
MAMiller
CLSnow

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

JDS

**ASARCO**

**Southwestern Exploration Division**

June 21, 1990

J.D. Sell

Yarnell Project
XRD Billing

The X-ray diffraction bill has arrived (Attach. 1). The bill is for work on the Yarnell Project (EA-0444) which consisted of analysis on the footwall green core, green clay (nontronite), and the fault gouge.

John J. Malusa

JJM:mek
Att.

Attch 1

THE UNIVERSITY OF ARIZONA
Tucson

# INVOICE

42965

Date June 20, 1990

Invoice No.

Mr. John J. Malusa
ASARCO Incorp.
P.O. Box 5747
Tucson, AZ 85703

Dept. Geo Sciences
Gould-Simpson, Bldg 77
U of A 85721
Attn: Business office

Please make check payable to
THE UNIVERSITY OF ARIZONA and mail to Department of: Geosciences, Gould/Simpson Bldg

5½ hours of X-ray diffraction analysis @$38.00/hr----------$209.00

OK for Payment
APPROVED FOR PAYMENT
James W Lee
(Signature)

Yarnell EA-0444

Please return one copy of invoice with your check.

JDS

**ASARCO**

**Southwestern Exploration Division**

June 22, 1990

T. E. Scartaccini

Addendum
Yarnell Project Exploration
and Option Payments
Yavapai County, Arizona

Please replace the last part of line 3 of paragraph 4 of my memo to you dated June 20, 1990.

Delete: ..., and you have authorized him to proceed.

Replace with: ..., as per the Asarco agreements.

James D. Sell

James D. Sell

JDS:mek

cc: R.L. Brown
W.L. Kurtz
S.L. Lakosky

JDS

**ASARCO**

**Southwestern Exploration Division**

June 20, 1990

T.E. Scartaccini

Yarnell Project Exploration
and Option Payments
Yavapai County, Arizona

Mr. R.L. Brown has verbally expressed that Mr. S.L. Lakosky, as present Yarnell Project Manager, and the Mining Department should be responsible for the various option payments and work schedules at the Yarnell Project.

The Exploration Department is clearing up the backlog of reports, working with the ECS block model configuration (with input from S.L. Lakosky, S.A. Anzalone, and L.J. Jansen), and going forward with patenting the Pennsylvania claim: but, otherwise, will have little future activity on the Yarnell Project without your prior approval.

The Exploration Department has copied to S.L. Lakosky the thoughts on further drilling at Yarnell, the work requirements on State Leases, etc. for his consideration and handling.

In S.L. Lakosky's memo of June 12, 1990 (Y-3.0) to you, he outlined the option payments due through July 1, 1991, ~~and you have authorized him to proceed~~ as per the ASARCO agreement. As stated previously, Mr. Brown agrees that the schedule is the Mining Department's responsibility.

James D. Sell

James D. Sell

JDS:mek

cc: R.L. Brown
W.L. Kurtz
S.L. Lakosky

JDS

**ASARCO**

**Southwestern Exploration Division**

June 25, 1990

W.D. Gay

Assessment Work
Yarnell Project
Yavapai County, AZ

As the Mining Department has taken over as Manager of the Yarnell Project, you should contact S.L. Lakosky and help prepare the Affidavits of Labor for all the Yarnell unpatented claims held in the project, for the year ending August 31, 1990.

James D. Sell, mek

James D. Sell

JDS:mek

cc: S.L. Lakosky
W.L. Kurtz
M.A. Miller

JDS

**ASARCO**

**Southwestern Exploration Division**

June 25, 1990

M.A. Miller

Report-Map of Assays
Condemnation Drilling Areas
Yarnell Project
Yavapai County, Arizona

Prepare a report and map showing all your structures, alteration thickness, and assays of samples within the three areas where S.L. Lakosky intends to place the waste dumps, and the several leach pad locations.

As they will do some condemnation drilling, this information will be useful for any test drilling work.

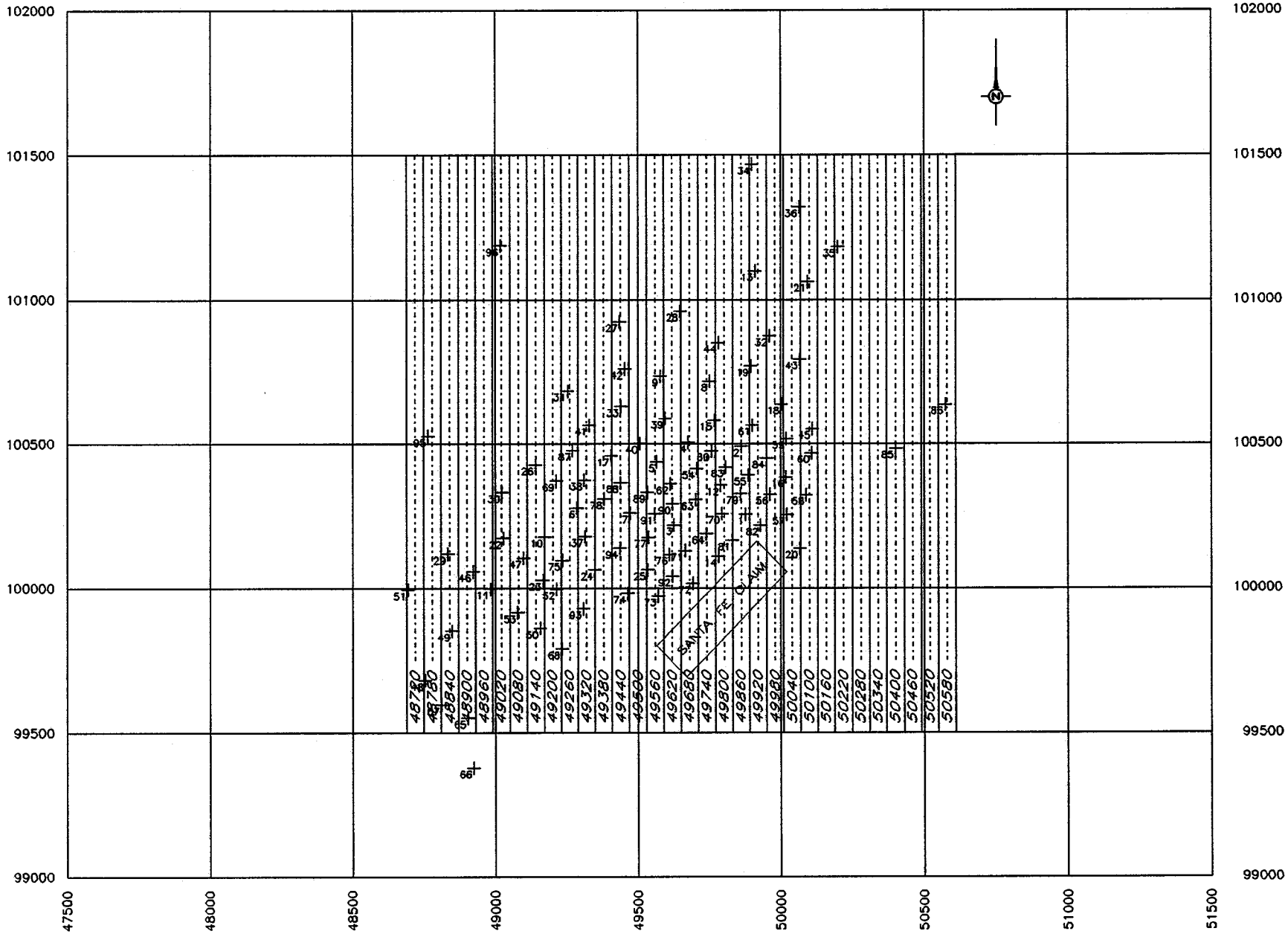
James D. Sell /mek

James D. Sell

JDS:mek

cc: W.L. Kurtz
S.L. Lakosky

# SECTION LOCATION MAP



GEOCHEMICAL SERVICES INC.

# GEOCHEMICAL ANALYSIS REPORT

TO: Mr. James D. Sell
ASARCO Inc.
P. O. Box 5747
Tucson, AZ 85703 tel:602/792-3010

==========

ASARCO Incorp
JUN 29 1990
SW Exploration

Job Number: ASB-0R1855
Analysis Code: SRP15
Digest: 15 gram
PROJECT: YARNELL
Total number of samples: 22

==========

This report has been reviewed and approved by:

Nancy G. Gonzalez for Date: 6/27/90
Mary Leitch, Quality Assurance Manager

cc: J. RASMUSSEN

3805 Atherton Road • Rocklin, California 95677 • 916/624-6000 1/800/827-4GSI FAX: 916/624-8986
1498 Kleppe Lane • Sparks, Nevada 89431 • 702/359-6600 FAX: 702/359-6605

GEOCHEMICAL SERVICES INC.

# GEOCHEMICAL ANALYSIS REPORT

JOB #: ASB-OR1855



| SAMPLE ID | # | Ag ppb | Au ppb | As ppm | Bi ppm | Cd ppm | Hg ppm | Sb ppm | Se ppm | Te ppm | Cu ppm | Mo ppm | Pb ppm | Zn ppm | Ga ppm | Tl ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YA 351 | 1 | 38.5 | 1.36 | 4.85 | .290 | .100 | <.019 | .480 | <.244 | <.049 | 16.9 | 1.01 | 18.4 | 69.0 | 5.87 | <.487 |
| YA 359 | 2 | 28.8 | <.6 | 4.98 | .266 | .124 | <.02 | .411 | <.245 | <.049 | 16.2 | 1.01 | 19.4 | 68.4 | 5.46 | <.49 |
| YA 361 | 3 | 47.2 | <.6 | 4.22 | .262 | .250 | <.02 | .482 | <.247 | .055 | 18.9 | 1.03 | 17.7 | 81.0 | 4.92 | <.494 |
| YA 367 | 4 | 31.2 | <.6 | 4.31 | .261 | .131 | <.02 | .393 | <.246 | <.049 | 15.2 | 1.56 | 19.0 | 61.0 | 5.50 | <.491 |
| YA 369 | 5 | 46.8 | .81 | 4.90 | .375 | .151 | <.02 | .364 | <.245 | .053 | 16.7 | .871 | 15.9 | 68.2 | 5.29 | <.49 |
| YA 371 | 6 | 51.4 | 1.23 | 2.74 | .247 | .153 | .022 | .368 | <.249 | .06 | 19.0 | .632 | 13.1 | 63.6 | 3.82 | <.498 |
| YA 377 | 7 | 37.6 | 1.09 | 3.96 | .222 | .095 | <.02 | .380 | <.246 | <.049 | 16.0 | .923 | 15.6 | 67.7 | 5.73 | <.492 |
| YA 379 | 8 | 32.4 | 1.06 | 3.03 | .211 | .156 | <.02 | .314 | <.246 | <.049 | 16.8 | .802 | 13.7 | 68.4 | 4.32 | <.492 |
| YA 383 | 9 | 44.7 | .663 | 4.98 | .321 | .142 | <.02 | .478 | <.248 | .051 | 17.1 | 1.08 | 19.5 | 69.2 | 5.18 | <.497 |
| YA 385 | 10 | 38.3 | 1.86 | 3.22 | .211 | .161 | <.02 | .323 | <.248 | <.05 | 16.0 | .815 | 13.1 | 59.0 | 3.99 | <.495 |
| YA 387 | 11 | 39.7 | 4.70 | 2.49 | .143 | .129 | <.02 | .232 | <.246 | <.049 | 15.7 | .671 | 10.3 | 58.3 | 3.66 | <.492 |
| YA 389 | 12 | 56.8 | 12.8 | 2.51 | .168 | .108 | <.02 | .245 | <.244 | <.049 | 14.8 | .601 | 12.5 | 53.8 | 3.30 | <.489 |
| YA 391 | 13 | 45.9 | 14.6 | 3.85 | .279 | .110 | <.02 | .392 | <.249 | .073 | 14.3 | .908 | 15.9 | 54.8 | 4.65 | <.498 |
| YA 393 | 14 | 37.6 | 1.20 | 2.34 | .168 | .148 | <.02 | .288 | <.25 | <.05 | 15.8 | .746 | 11.3 | 64.8 | 3.36 | <.499 |
| YA 395 | 15 | 19.9 | 5.68 | 2.70 | .316 | .105 | <.02 | .267 | <.245 | <.049 | 10.4 | .636 | 11.2 | 51.1 | 3.78 | <.49 |
| YA 397 | 16 | 26.1 | 1.17 | 2.86 | .227 | .119 | <.019 | .375 | <.244 | <.049 | 11.4 | .798 | 13.0 | 59.8 | 3.90 | <.487 |
| YA 399 | 17 | 40.3 | .952 | 2.80 | .201 | .156 | <.02 | .339 | <.25 | .07 | 14.7 | .850 | 14.1 | 68.5 | 3.84 | <.499 |
| YA 401 | 18 | 36.0 | 23.8 | 3.61 | .259 | .102 | <.02 | .271 | <.245 | <.049 | 15.0 | .740 | 15.8 | 65.9 | 4.68 | <.49 |
| YA 413 | 19 | 47.6 | 1.18 | 3.84 | .211 | .098 | <.02 | .331 | <.245 | .051 | 17.2 | .726 | 17.2 | 65.0 | 5.14 | <.489 |
| YA 415 | 20 | 41.7 | 12.2 | 4.13 | .193 | .065 | <.02 | .287 | <.249 | .053 | 11.5 | 1.06 | 11.8 | 41.3 | 4.01 | <.497 |
| YA 425 | 21 | 35.3 | 3.18 | 3.22 | .202 | .121 | <.02 | .319 | <.248 | <.05 | 14.9 | .764 | 13.7 | 61.8 | 5.00 | <.496 |
| YA 427 | 22 | 26.7 | 1.29 | 3.54 | .193 | .085 | <.02 | .233 | <.247 | <.049 | 10.6 | .847 | 12.8 | 45.7 | 3.32 | <.494 |

3805 Atherton Road • Rocklin, California 95677 • 916/624-6000 1/800/827-4GSI FAX: 916/624-8986
1498 Kleppe Lane • Sparks, Nevada 89431 • 702/359-6600 FAX: 702/359-6605

GEOCHEMICAL SERVICES INC.

# GEOCHEMICAL ANALYSIS REPORT

TO: Mr. James D. Sell
ASARCO Inc.
P. O. Box 5747
Tucson, AZ 85703 tel:602/792-3010

Job Number: ASB-OR1855
Analysis Code: SRP15
Digest: 15 gram
PROJECT: YARNELL
Total number of samples: 22

This report has been reviewed and approved by:

Nancy G. Gonzalez for Date: 6/27/90
Mary Leitch, Quality Assurance Manager

ASARCO Incorp.
JUN 27 1990
SW Exploration

3805 Atherton Road • Rocklin, California 95677 • 916/624-6000 1/800/827-4GSI FAX: 916/624-8986
1498 Kleppe Lane • Sparks, Nevada 89431 • 702/359-6600 FAX: 702/359-6605

1 of 5

GSI GEOCHEMICAL SERVICES INC.

# GEOCHEMICAL ANALYSIS REPORT

JOB #: AS8-0R1855



| SAMPLE ID | # | Ag ppb | Au ppb | As ppm | Bi ppm | Cd ppm | Hg ppm | Sb ppm | Se ppm | Te ppm | Cu ppm | Mo ppm | Pb ppm | Zn ppm | Ga ppm | Tl ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YA 351 | 1 | 38.5 | 1.36 | 4.85 | .290 | .100 | <.019 | .480 | <.244 | <.049 | 16.9 | 1.01 | 18.4 | 69.0 | 5.87 | <.487 |
| YA 359 | 2 | 28.8 | <.6 | 4.98 | .266 | .124 | <.02 | .411 | <.245 | <.049 | 16.2 | 1.01 | 19.4 | 68.4 | 5.46 | <.49 |
| YA 361 | 3 | 47.2 | <.6 | 4.22 | .262 | .250 | <.02 | .482 | <.247 | .055 | 18.9 | 1.03 | 17.7 | 81.0 | 4.92 | <.494 |
| YA 367 | 4 | 31.2 | <.6 | 4.31 | .261 | .131 | <.02 | .393 | <.246 | <.049 | 15.2 | 1.56 | 19.0 | 61.0 | 5.50 | <.491 |
| YA 369 | 5 | 46.8 | .81 | 4.90 | .375 | .151 | <.02 | .364 | <.245 | .053 | 16.7 | .871 | 15.9 | 68.2 | 5.29 | <.49 |
| YA 371 | 6 | 51.4 | 1.33 | 2.74 | .247 | .153 | .022 | .368 | <.249 | .06 | 19.0 | .632 | 13.1 | 63.6 | 3.82 | <.498 |
| YA 377 | 7 | 37.6 | 1.09 | 3.96 | .222 | .095 | <.02 | .380 | <.246 | <.049 | 16.0 | .923 | 15.6 | 67.7 | 5.73 | <.492 |
| YA 379 | 8 | 32.4 | 1.06 | 3.03 | .211 | .156 | <.02 | .314 | <.246 | <.049 | 16.8 | .802 | 13.7 | 68.4 | 4.32 | <.492 |
| YA 383 | 9 | 44.7 | .663 | 4.98 | .321 | .142 | <.02 | .478 | <.248 | .051 | 17.1 | 1.08 | 19.5 | 69.2 | 5.18 | <.497 |
| YA 385 | 10 | 38.3 | 1.66 | 3.22 | .211 | .161 | <.02 | .323 | <.248 | <.05 | 16.0 | .815 | 13.1 | 59.0 | 3.99 | <.495 |
| YA 387 | 11 | 39.7 | 4.70 | 2.49 | .143 | .129 | <.02 | .232 | <.246 | <.049 | 15.7 | .671 | 10.3 | 58.3 | 3.66 | <.492 |
| YA 389 | 12 | 56.8 | 12.8 | 2.51 | .168 | .108 | <.02 | .245 | <.244 | <.049 | 14.8 | .601 | 12.5 | 53.8 | 3.30 | <.489 |
| YA 391 | 13 | 45.9 | 14.6 | 3.85 | .279 | .110 | <.02 | .392 | <.249 | .073 | 14.3 | .908 | 15.9 | 54.8 | 4.65 | <.498 |
| YA 393 | 14 | 37.6 | 1.20 | 2.34 | .168 | .148 | <.02 | .288 | <.25 | <.05 | 15.8 | .746 | 11.3 | 64.8 | 3.36 | <.499 |
| YA 395 | 15 | 19.9 | 5.68 | 2.70 | .316 | .105 | <.02 | .267 | <.245 | <.049 | 10.4 | .636 | 11.2 | 51.1 | 3.78 | <.49 |
| YA 397 | 16 | 26.1 | 1.17 | 2.86 | .227 | .119 | <.019 | .375 | <.244 | <.049 | 11.4 | .798 | 13.0 | 59.8 | 3.90 | <.487 |
| YA 399 | 17 | 40.3 | .952 | 2.80 | .201 | .156 | <.02 | .339 | <.25 | .07 | 14.7 | .850 | 14.1 | 68.5 | 3.84 | <.499 |
| YA 401 | 18 | 36.0 | 23.8 | 3.61 | .259 | .102 | <.02 | .271 | <.245 | <.049 | 15.0 | .740 | 15.8 | 65.9 | 4.68 | <.49 |
| YA 413 | 19 | 47.6 | 1.18 | 3.84 | .211 | .098 | <.02 | .331 | <.245 | .051 | 17.2 | .726 | 17.2 | 65.0 | 5.14 | <.489 |
| YA 415 | 20 | 41.7 | 12.2 | 4.13 | .193 | .065 | <.02 | .287 | <.249 | .053 | 11.5 | 1.06 | 11.8 | 41.3 | 4.01 | <.497 |
| YA 425 | 21 | 35.3 | 3.18 | 3.22 | .202 | .121 | <.02 | .319 | <.248 | <.05 | 14.9 | .764 | 13.7 | 61.8 | 5.00 | <.496 |
| YA 427 | 22 | 26.7 | 1.29 | 3.54 | .193 | .085 | <.02 | .233 | <.247 | <.049 | 10.6 | .847 | 12.8 | 45.7 | 3.32 | <.494 |

ASARCO Incorporate
JUN 2 7 1990
SW Exploration

3805 Atherton Road • Rocklin, California 95677 • 916/624-6000 1/800/827-4GSI FAX: 916/624-8986
1498 Kleppe Lane • Sparks, Nevada 89431 • 702/359-6600 FAX: 702/359-6605

6-29-90

# NORGOLD RESOURCES INC.

U.S. OFFICES:
13935 Chamy Drive
Reno, Nevada
89511
(702) 851-3177
Fax: (702) 851-3177

HEAD OFFICE:
210 - 475 Howe Street
Vancouver, B.C.
V6C 2B3
(604) 681-5566
Fax: (604) 687-8789

June 29, 1990

ASARCO Incorporated
JUL 9 1990
SW Exploration

Mr. Jim Sell
ASARCO Incorporated
1150 North 7th Avenue
P.O. Box 5747
Tucson, Arizona
85703

Dear Jim:

Re: Option Agreement - Harper/Hayt et al
Tower Relocation Site - Yarnell Project

I was reviewing Norgold's agreement concerning the Yarnell Project and noted that the Option Agreement between Mr. & Mrs. Harper/Hayt may not have been forwarded to ASARCO. This Option Agreement covers properties that will likely be utilized in the relocation of the Maricopa County and Santa Fe Railway communication towers. Norgold has committed $2,500 for a one year option on these properties, effective October 20, 1989, at which time we would commit to the outright purchase of such properties and title to ingress and egress.

I cannot find in our files correspondence with ASARCO acknowledging the receipt of such agreements. Assuming this to be the case, ASARCO should reimburse Norgold for the option payment. I have enclosed a copy of Norgold's returned cheque for verification of such payment.

In another matter concerning property, Norgold is in receipt of signed agreements from the Atchison, Topeka and Santa Fe Railway Company concerning the Option Agreement to relocate Santa Fe's microwave tower at Yarnell, Arizona. I will forward the agreements to Dick Brown for signature.

Thank you for looking into this matter for us.

Sincerely,

Michael D. Philpot
Chairman of the Board

**Bank of Montreal**

VANCOUVER MAIN OFFICE
FIRST BANK TOWER, 595 BURRARD ST.
VANCOUVER, B.C. V7X 1L7

Ch. No 0038

Date October 20th 19

U.S. $2500.00

Pay to the order of E. HARPER, F. HARPER, L. HAYT & E. HAYT U.S. $ 2,500.00

— Two thousand Five hundred —**/100 United States Dollars

ROYAL BANK OF CANADA
OCT 23 1979
CORR. BANKING

United States Dollar Account.

per

⑈0038⑈ ⑆00040⑉001⑆ 4618⑉901⑈ Norgo ⑈0000250000⑈

In Document Book
Yarnell 90-5
Received Dec 18, 1989
from Brian D Edgar.

# OPTION AGREEMENT

THIS AGREEMENT is made effective as of the 20 day of October, 1989, by and between EUGENE C. HARPER and FLORENCE A. HARPER, husband and wife, and LESTER J. HAYT, SR., and ELOISE G. HAYT, husband and wife (collectively as "Owners") and NORGOLD RESOURCES (US) INC., a Nevada corporation authorized to do busines in Arizona (as "Optionee").

WHEREAS, Owners represent to Optionee that they are the owners of, and are willing to grant to Optionee the sole and exclusive option to purchase, the hereinafter described parcels of real property situated in Yavapai County, Arizona, all as more particularly described as Parcel One and Parcel Two in Exhibit A attached hereto and made a part hereof; and

WHEREAS, in the event Optionee exercises one or both of its options to purchase, Owners are willing to grant to Optionee an Easement Agreement for ingress to and egress from the property described in Exhibit A and for construction, use and maintenance of utilities to serve the same across adjacent real property owned by Owners;

NOW, THEREFORE, for a good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged by Owners, Owners and Optionee agree as follows:

1. Term; Option Payment

Unless Optionee sooner exercises its option to purchase as hereinafter provided, the term of this Agreement shall be for a period expiring on the date twelve (12) months from the effective

date hereof (the "Option Period"). Upon execution of this Agreement by Owners and Optionee, Optionee shall pay to Owners the sum of Two Thousand Five Hundred Dollars ($2,500.00) as consideration for the purchase options granted herein.

2. Grant; Exercise of Options; Purchase Price

Owners hereby grant to Optionee the sole exclusive rights and options, exercisable at any time prior to expiration of the Option Period, to (1) purchase Parcel One, or (2) purchase Parcel Two, or (3) purchase both Parcels One and Parcel Two, by giving written notice to Owners in the manner hereinafter set forth of Optionee's election to purchase, which notice shall designate the Parcel or Parcels which Optionee elects to purchase and shall designate a title insurance company with offices in Yavapai County to act as escrow agent for the closing of the purchase. If Optionee elects to purchase only Parcel One, the purchase price shall be the sum of Ten Thousand Dollars ($10,000.00). If Optionee elects to Purchase only Parcel Two, the purchase price shall be the sum of Five Thousand Dollars ($5,000.00). If Optionee elects to purchase both Parcel One and Parcel Two, the purchase price shall be the sum of Fifteen Thousand Dollars ($15,000.00). Promptly following exercise by Optionee of its option to purchase, the parties shall execute and deliver to the escrow agent, escrow instructions consistent with their Agreement, which instructions shall direct escrow agent to close the escrow within thirty (30) days of establishing the escrow. Owners shall thereupon execute and deliver into escrow a Warranty Deed of the applicable Parcel or Parcels, warranting title as against all liens and encumberances other than as set forth in Exhibit A and Optionee shall deliver into escrow the applicable purchase price set forth above. The parties shall also execute and deliver into escrow an Easement Agreement in the form attached as Exhibit B, together with an affidavit of value as required under the laws of the State of Arizona. Real property taxes shall be prorated as of the date of closing and the escrow

agent shall deliver to Optionee a policy of title insurance, insuring Optionee's title as herein represented. The cost of the title policy shall be the responsibility of Owners and the costs of escrow shall be divided between the parties. Upon closing of the escrow this Agreement shall terminate.

3. Examination by Optionee; Indemnity

Optionee shall have the right, at any time prior to the expiration of the Option Period, to enter upon, examine and survey the real property described in Exhibit A. In the event Optionee enters thereon during the Option Period to examine or survey the property, it shall conduct work performed thereon in a good and workmanlike manner and in compliance with all applicable local, state and federal statutes. Optionee shall pay all expenses incurred by it in its operations thereon and shall allow no liens arising from any act of Optionee to remain upon the said real property. Optionee shall indemnify Owner against and hold Owner harmless from any liability to third persons resulting from Optionee's operations hereunder.

4. Notices

Any notice or communication required or permitted hereunder shall be effective when personally delivered or shall be effective when addressed:

If to Owner:

c/o Eugene G. Harper
P.O. Box 4169
Cave Creek, AZ 85331

If to Optionee:

Norgold Resources (US) Inc.
2380 Harbour Centre
P.O. Box 12122
555 W. Hastings Street
Vancouver, B.C. V6B 4N6

and deposited, postage prepaid, and registered, in the United States or Canadian mail, as the case may be. Either party may, by notice to the other given as aforesaid, change its mailing address for future notices hereunder.

5. Construction, Memorandum; Inurement

This Agreement, and the rights and obligations of the parties hereunder, shall be governed by the laws of the State of Arizona. Section headings in this Agreement are for convenience only and shall not be considered a part of this Agreement or used in its interpretation. The parties shall join in the execution of a Memorandum of this Agreement in a form sufficient to constitute notice hereof to third parties under the laws of the State of Arizona. This Agreement shall inure to the benefit of and be binding upon the respective heirs, devisees, personal representatives, successors and assigns of the parties hereto.

IN WITHNESS WHEREOF, this OPTION AGREEMENT has been executed as of the date first above set forth.

OWNERS

Eugene C. Harper

Eugene C. Harper

Lester J. Hayt, Sr.

Florence A. Harper

Florence A. Harper

Eloise G. Hayt

OPTIONEE

NORGOLD RESOURCES (US) INC.

By

Its: Secretary & Director

STATE OF ARIZONA )
) ss.
COUNTY OF Maricopa )

The foregoing instrument was acknowledged before me this 22nd day of September, 1989, by Eugene C. Harper and Florence A. Harper, husband and wife.

Notary Public

My Commission Expires: June 5, 1992

STATE OF ARIZONA )
) ss.
COUNTY OF Maricopa )

The foregoing instrument was acknowledged before me this 22nd day of September, 1989, by Lester J. Hayt, Sr., and Eloise G. Hayt, husband and wife.

Notary Public

My Commission Expires: June 5, 1992

PROVINCE OF )
) ss.
BRITISH COLUMBIA )

The foregoing instrument was acknowledged before me this 20th day of October, 1989 by Michael D. Philpot, the Secretary & Director of Norgold Resources (US) Inc., a Nevada corporation, on behalf of the corporation.

Notary Public

My Commission Does Not Expire:

# EXHIBIT A

EXHIBIT A to OPTION AGREEMENT (and Memorandum thereof) being a description of the real property subject to the said Option Agreement and Memorandum:

## PARCEL ONE

That portion of the Southwest Quarter of the Southeast Quarter of Section 11, Township 10 North, Range 5 West, Gila and Salt River Meridian, Yavapai County, Arizona, described as follows:

BEGINNING at a point on the South line of said Section 11, from which the South Quarter corner bears North 89° 55' West, 96.20 feet;

thence North 0° 05' East, 208.71 feet;

thence South 89° 55' East, 208.71 feet to a point, such point being the northwest corner of the property described in instrument recorded in Book 387 of Official Records, page 502, records of Yavapai County, Arizona;

thence South 0° 05' West, 208.71 feet along the East line of the last referenced property to a point on the South line of said Section;

thence North 89° 55' West along said South line, 208.71 feet, to the POINT OF BEGINNING;

containing one acre, more or less.

EXCEPT all coal and other minerals as reserved in Patent from United States of America.

## PARCEL TWO

That portion of the Southwest Quarter of the Southeast Quarter of Section 11, Township 10 North, Range 5 West, Gila and Salt River Meridian, Yavapai County, Arizona, described as follows:

BEGINNING at a point on the South line of said Section 11, from which the South Quarter corner bears North 89° 55' West, 617.98 feet, and being the southeast corner of the property described in instrument recorded in

Book 1530 of Official Records, page 629, records of Yavapai County, Arizona;

thence North 0° 05' East along the East line of the last referenced property, 104.36 feet to a point on the East line of said property;

thence South 89° 55' East 208.71 feet;

thence South 0° 05' West, 104.36 feet to a point on the South line of said Section;

thence North 89° 55' West along said South line, 208.71 feet, to the POINT OF BEGINNING;

containing one-half acre, more or less.

EXCEPT all coal and other minerals as reserved in Patent from United States of America.

BOTH OF WHICH PARCELS ARE SUBJECT TO:

1. All existing roads, rights of way and easements and those of record in the office of the Recorder of Yavapai County, Arizona;

2. All taxes which may constitute a lien but which are not yet due and payable; and

3. Exceptions and reservations in the United States Patent thereto.

EXHIBIT B

EASEMENT AGREEMENT

The undersigned, EUGENE C. HARPER and FLORENCE A. HARPER, husband and wife, and LESTER J. HAYT, SR. and ELOISE G. HAYT, husband and wife (collectively as "Grantors"), being the owners of the real property included within Tax Parcel 203-07-37B situated in the Southeast Quarter of Section 11, Township 10 North, Range 5 West, Gila and Salt River Meridian, Yavapai County, Arizona hereby grant a non-exclusive easement for ingress and egress across and over the real property included within Tax Parcel 203-07-37B (but specifically excepting and excluding those portions of the Southeast Quarter within Tax Parcel 203-07-37A, Tax Parcel 203-07-38 and Plat C Amended of Yarnell) to NORGOLD RESOURCES (US) INC., a Nevada corporation ("Norgold"), the buyer of that portion of said Tax Parcel 203-07-37B described in Schedule A attached hereto and made a part hereof, such easement being granted herein in an undefined manner and to encompass those portions of the existing roadway heretofore used to service communication facilities within Tax Parcels 203-07-37A and 203-07-38. At such time as development of Grantors' remaining property within Tax Parcel 203-07-37B takes place, Norgold agrees to accept ingress and egress from the nearest developed street that will permit vehicle travel to the real property described in Schedule A.

Owners further hereby grant to Norgold a temporary utility easement across the real property included within Tax Parcel 203-07-37B (but specifically excepting and excluding those portions of the Southeast Quarter within Tax Parcel 203-07-37A, Tax Parcel 203-07-38 and Plat C Amended of Yarnell) for the construction, use and maintenance of utilities to service any facilities placed by Norgold on the property described in Schedule A until such time, if any, as developments takes place resulting in bordering

sources of utilities being made available to Norgold for such purposes.

This Agreement and the conditions hereof shall inure to the benefit of and be binding upon Grantors and Norgold and their respective heirs, devisees, personal representatives, successor and assigns as the same relates to the property included within Tax Parcel 203-07-37B.

DATED: October 20, 1989

Eugene A. Harper, Grantor

Florence A. Harper, Grantor

Lester J. Hayt, Sr. Grantor

Eloise G. Hayt, Grantor

Accepted:

NORGOLD RESOURCES (US) INC.

By:

Its: Secretary & Director

Note: Add Schedule A ( description of property purchased by Norgold) and acknowledgments at time of execution of the Easement Agreement.

JDS

APKER, APKER, HAGGARD & KURTZ, P.C.
P. O. Box 10280
Phoenix, Arizona 85064-0280
(602) 381-0085

Exploration Dept. SW U.S. Division
ASARCO Incorporated
P.O. Box 5747
Tucson, Arizona 85703

July 1, 1990
Page 1
Client: 111-4
Matter: 1

Matter: GENERAL

| Date | Professional Services Rendered — only 2 minutes | |
|---|---|---|
| 06/05/90 | Telephone conference with Mr. Gay re requirements for amended location notices in Utah. | |
| 06/15/90 | Telephone conference with Mr. Gay re patent of Pennsylvania claim. | |
| 06/18/90 | Review mining claim patent procedures; prepare correspondence and forms for Mr. Gay for patenting Pennsylvania claim. | |
| | Total Services | 391.00 |

Remove 444-04

COPY

TABLE D

duplicates from reruns of previous holes

| hole # (m- ) | interval (feet) | A ($10^{-3}$ opt) | B ($10^{-3}$ opt) | To be in McClelland's assay 7-80 report date |
|---|---|---|---|---|
| 5 | 128-131 | 014 | | 3/28 |
| 94 | 21-24 | 022 | | 9/30 |
| 10 | 196-197 | | 007 | 6/5 |
| 89 | 221-224 | | 005 | 9/26 |
| 10 | 237-239 | | 007 | 6/5 |
| 89 | 1-4 | | 005 | 9/26 |
| 11 | 22-24 | | 004 | 6/6 |
| 77 | 131-134 | | 005 | 9/12 |
| 86 | 1-3 | | 007 | 9/23 |
| 14 | 1-4 | 025 | | 6/8 |
| 91 | 21-24 | 021 | | 9/28 |
| 14 | 26-29 | 025 | | 6/8 |
| 96 | 531-534 | 021 | | 10/4 |
| 14 | 121-124 | 026 | | 6/7 |
| 95 | 21-24 | 021 | | 10/3 |
| 17 | 253-254 | | 008 | 6/10 |
| 73 | 21-24 | | 007 | 9/10 |
| 17 | 371-372 | 025 | | 6/10 |
| 83 | 7-9 | 022 | | 9/21 |

| Hole # (ym- ) | interval (feet) | A ($10^{-3}$ opt) | B ($10^{-3}$ opt) | assay report date |
|---|---|---|---|---|
| 07 | 421-423 | | .008 | 6/10 |
| 82 | 16-17 | | .007 | 9/20 |
| 18 | 157-159 | | .008 | 6/11 |
| 72 | 101-104 | | .008 | 9/9 |
| 21 | 3-4 | .023 | | 6/13 |
| 88 | 21-24 | .022 | | 9/25 |
| 21 | 51-54 | .020 | | 6/13 |
| 80 | 201-204 | .021 | | 9/17 |
| 22 | 181-183 | ~~.004~~ | .004 | 6/14 |
| 78 | 147-149 | ~~.004~~ .008 | ~~.008~~ [redacted] | 9/13 |
| 22 | 328-329 | | .012 | 6/14 |
| 80 | 21-24 | | .007 | 9/17 |
| 23 | 51-53 | .026 | | 6/15 |
| 83 | 207-209 | .022 | | 9/21 |
| 28 | 227-228 | | .007 | 6/25 |
| 65 | 101-103 | ~~.004~~ .004 | ~~.004~~ [redacted] | 9/1 |
| 77 | 21-24 | | .007 | 9/12 |
| 84 | 11-13 | | .007 | 9/22 |
| 30 | 162-164 | | .008 | 6/27 |
| 93 | 21-24 | | .008 | 9/29 |

| Hole # (4m-) | interval (feet) | A ($10^{-3}$ opt) | B ($10^{-3}$ opt) | assay report date |
|---|---|---|---|---|
| 01 | 7-9 | .024 | | 6/28 |
| 90 | 221-224 | .016 | | 9/27 |
| 32 | 2-4 | .026 | | 6/29 |
| 94 | 191-194 | .020 | | 10/16 |
| 32 | 196-199 | | .008 | 6/29 |
| 78 | 271-274 | | .008 | 9/13 |
| 86 | 51-53 | | .006 | 9/23 |
| 35 | 91-94 | .004 | | 7/4 |
| 86 | 101-103 | .021 | | 9/23 |
| 37 | 51-54 | | .008 | 7/19 |
| 74 | 71-74 | | .007 | 9/10 |
| 80 | 101-104 | | .007 | 9/17 |
| 38 | 1-4 | .022 | | 7/20 |
| 64 | 21-23 | .024 | | |
| 38 | 61-64 | | .008 | 7/20 |
| 71 | 71-73 | | .005 | 9/9 |
| 77 | 71-74 | | .008 | 9/12 |
| 96 | 497-499 | | .008 | 10/4 |
| 38 | 101-104 | .028 | | 7/20 |
| 81 | 136-138 | .023 | | 9/20 |
| 90 | 121-124 | .019 | | 9/27 |

| Hole # (m →) | interval (feet) | A ($10^{-3}$ opt) | B ($10^{-3}$ opt) | assay report date |
|---|---|---|---|---|
| 7[illegible] | 251-254 | | 007 | 7/20 |
| 80 | 291-294 | | 008 | 9/17 |
| 83 | 237-239 | | 006 | 9/21 |
| | | | | |
| 39 | 12-14 | 022 | | 7/21 |
| 88 | 201-204 | 021 | | 9/25 |
| | | | | |
| 39 | 101-104 | | 008 | 7/21 |
| 64 | 181-183 | | 008 | 8/31 |
| 73 | 71-74 | | 008 | 9/10 |
| | | | | |
| 39 | 191-194 | 021 | | 7/21 |
| 65 | 11-13 | 021 | | 8/31 |
| | | | | |
| 40 | 51-54 | 025 | | 7/24 |
| 64 | 151-153 | 022 | | 8/31 |
| | | | | |
| 40 | 151-154 | | 008 | 7/24 |
| 64 | 101-103 | | 009 | 8/31 |
| | | | | |
| 40 | 202-204 | 023 | | 7/24 |
| 70 | 21-24 | 021 | | 9/8 |
| 79 | 101-104 | 022 | | 9/14 |
| 87 | 203-204 | 014 | | 9/24 |
| | | | | |
| 40 | 301-304 | | 008 | 7/24 |
| 65 | 51-53 | | 020 | 8/31 |

| Hole # ym- ) | interval (feet) | A ($10^{-3}$ opt) | B ($10^{-3}$ opt) | assay report date |
|---|---|---|---|---|
| 41 | 17-19 | .030 | | 7/25 |
| 89 | 121-124 | 019 | | 9/26 |
| | | | | |
| 41 | 362-364 | | .007 | 7/25 |
| 79 | 181-184 | | .008 | 9/14 |
| 85 | 7-9 | | 008 | 9/22 |
| | | | | |
| 42 | 11-14 | 017 | | 7/27 |
| 72 | 21-24 | 025 | | 9/9 |
| | | | | |
| 42 | 291-293 | | 008 | 7/27 |
| 95 | 321-324 | | 006 | 10/3 |
| | | | | |
| 43 | 11-13 | 024 | | 7/28 |
| 75 | 151-154 | 022 | | 9/11 |
| 89 | 321-324 | 021 | | 9/26 |
| | | | | |
| 43 | 91-94 | 022 | | 7/28 |
| 74 | 121-124 | 022 | | 9/10 |
| 79 | 1-4 | 023 | | 9/14 |
| | | | | |
| 43 | 121-124 | | 007 | 7/28 |
| 72 | 71-74 | | 007 | 9/9 |
| | | | | |
| 44 | 7-9 | 022 | | 7/28 |
| 60 | 171-174 | 025 | | 9/7 |

| Hole # (4M-) | interval (feet) | A ($10^{-3}$ opt) | B ($10^{-3}$ opt) | assay report date |
|---|---|---|---|---|
| 41 | 103-104 | | 008 | 7/28 |
| 66 | 41-43 | | 007 | 9/1 |
| 82 | 91-93 | | 008 | 9/20 |
| | | | | |
| 44 | 197-199 | 025 | | 7/28 |
| 84 | 121-123 | 023 | | 9/22 |
| | | | | |
| 44 | 251-254 | | 008 | 7/28 |
| 67 | 71-73 | | 007 | 9/1 |
| 78 | 73-74 | | 008 | 9/13 |
| 91 | 121-124 | | 007 | 9/28 |
| | | | | |
| 45 | 21-24 | 022 | | 8/3 |
| 76 | 21-24 | 022 | | 9/11 |
| | | | | |
| 45 | 92-93 | | 007 | 8/3 |
| 81 | 91-92 | | 008 | 9/20 |
| 84 | 191-193 | | 007 | 9/22 |
| | | | | |
| 46 | 0-3 | 023 | | 8/10 |
| 70 | 161-164 | 022 | | 9/8 |
| 78 | 3-4 | 022 | | 9/13 |
| | | | | |
| 46 | 91-93 | | 008 | 8/10 |
| 70 | 121-124 | | 006 | 9/8 |
| | | | | |
| 46 | 157-159 | 025 | | 8/10 |
| 92 | 31-34 | 022 | | 9/28 |

| Hole # (rm-) | interval (feet) | A ($10^{-3}$ opt) | B ($10^{-3}$ opt) | assay report date |
|---|---|---|---|---|
| 4[illegible] | 291-293 | | .007 | 8/10 |
| 87 | 103-104 | | .007 | 9/24 |
| 93 | 81-84 | | .006 | 9/29 |
| | | | | |
| 47 | 1-3 | .028 | | 8/11 |
| 96 | 31-34 | .021 | | 10/2 |
| | | | | |
| 47 | 101-103 | | .007 | 8/11 |
| 83 | 77-79 | | .007 | 9/21 |
| 95 | 121-124 | | .007 | 10/3 |
| | | | | |
| 49 | 201-203 | .025 | | 8/17 |
| 66 | 21-23 | .024 | | 9/1 |
| | | | | |
| 50 | 71-73 | | .004 | 8/17 |
| 68 | 121-123 | | .007 | 9/2 |
| 78 | 201-204 | | .009 | 9/13 |
| | | | | |
| 51 | 0-3 | .030 | | 8/17 |
| 71 | 21-23 | .022 | | 9/9 |
| | | | | |
| 51 | 101-103 | | .008 | 8/17 |
| 68 | 71-73 | | .008 | 9/2 |
| 69 | 371-374 | | .008 | 9/8 |
| | | | | |
| 5[illegible] | 201-203 | .025 | | 8/17 |
| 68 | 21-23 | .022 | | 9/2 |

| Hole # (ym-) | interval (feet) | A ~~10^-3~~ opt | B ~~10^-3~~ opt | assay report date |
|---|---|---|---|---|
| 53 | 101-103 | | .008 | 8/18 |
| 69 | 76-79 | | 010 | 9/3 |
| 54 | 1-3 | 024 | | 8/20 |
| 95 | 221-224 | 022 | | 10/3 |
| 61 | 21-23 | (004) | ~~007~~ | 8/24 |
| 90 | 21-24 | 016 | ~~016~~ | 9/27 |
| 62 | 321-323 | | 007 | 8/25 |
| 92 | 131-134 | | 007 | 9/28 |
| 69 | 271-274 | =15, 151-154 | 007 | 9/7 |
| 75 | 101-104 | | 007 | 9/11 |
| 74 | 21-24 | ym 5, 51-53 015 | | 9/10 |
| 81 | 18-19 | 020 | | 9/20 |
| 75 | 201-204 | =15, 151-154 | 008 | 9/11 |
| 87 | 303-304 | | 007 | 9/24 |
| 76 | 71-74 | =16, 31-34 | 008 | 9/11 |
| 84 | 91-93 | | 007 | 9/22 |
| 76 | 101-104 | 14, 31-34 | 007 | 9/11 |
| 90 | 121-124 | | 009 | 10/16 |

| Hole # (YM- ) | interval (feet) | A ($10^{-3}$ opt) | B ($10^{-3}$ opt) | assay report date |
|---|---|---|---|---|
| 79 | 61-64 | ypm 15, 301-304 | .007 | 9/14 |
| 88 | 101-104 | | .007 | 9/25 |
| 82 | 141-143 | ypm 4, 2111-2114 | .008 | 9/20 |
| 96 | 131-134 | ypm | .006 | 10/2 |

# ~~Attachment~~ KAYLE A

To be in Mullen's hand?
7-90

| hole # | interval (feet) | A (opt) | B (opt) | |
|---|---|---|---|---|
| ym 1 | no standards | | | |
| ym-2 | 103 - 105 | .015 | .015 | |
| | 177 - 179 | .007 | .007 | |
| | 218 - 221 | .003 | .003 | |
| | 307 - 309 | .005 | .005 | |
| ym-3 | 51 - 53 | | .004 | |
| | 121 - 123 | | .004 | |
| | 161 - 163 | | .005 | |
| ym-4 | ~~116.5 - 118~~ | ~~.020~~ | ~~.007~~ | |
| | ~~318 - 319~~ | | | |
| | ~~222 - 224~~ | ~~.015~~ | ~~.008~~ | |
| | ~~407 - 409~~ | | | |
| ym-5 | 51 - 53 | .005 | .005 | |
| | 128 - 131 | .014 | | |
| | 177 - 179 | .016 | | |
| | 208 - 211 | .020 | | |
| | 237 - 239 | .021 | | |
| | 273 - 277 | .008 | .008 | |
| ym-6 | 56 - 59 | .004 | .004 | |
| | 127 - 129 | .004 | .004 | |
| | 237 - 239 | .003 | .003 | |
| | 381 - 383 | .014 | | |
| ym-7 | 53 - 57 | .004 | .004 | |
| | 151 - 153 | .004 | .004 | |
| | 217 - 219 | .003 | .003 | |
| ym-8 | no standards | | | |
| ym-9 | 51 - 53 | .008 | .008 | |
| | 153 - 154 | | .009 | |
| | 237 - 239 | | NIL | |
| | 331 - 332 | .026 | | |

| hole # | interval (feet) | A(opt) | B(opt) |
|---|---|---|---|
| ym 10 | 98-99 | | .007 |
| | 196-197 | | .007 |
| | 237-239 | | .007 |
| ym-11 | 22-24 | | 004 |
| | 101-103 | | 004 |
| | 176-179 | | nil |
| ym-12 | 76-79 | | .008 |
| | 151-154 | | TR |
| | 201-204 | | .007 |
| ym-13 | no standards | | |
| ym-14 | 1-4 | .025 | |
| | 26-29 | .025 | |
| | 91-94 | .025 | |
| | 121-124 | .026 | |
| ym-15 | 6-9 | 025 | |
| | 91-94 | 022 | |
| | 241-244 | 025 | |
| ym-16 | 6-9 | 025 | |
| | 76-79 | 025 | |
| ym-17 | 77-79 | 024 | |
| | 183-184 | | 008 |
| | 253-254 | | 008 |
| | 421-423 | | 008 |
| | 371-372 | 025 | |
| ym-18 | 17-19 | 026 | |
| | 78-79 | 023 | |
| | 157-159 | | 008 |
| | 226-228 | | 004 |

| hole # | interval (feet) | A (opt) | B (opt) |
|---|---|---|---|
| ym 19 | 17-19 | .024 | |
| | 76-78 | | .014 |
| | 187-189 | .025 | |
| | 253-254 | | .009 |
| ym-20 | 1-4 | .021 | |
| | 57-59 | | .007 |
| ym-21 | 3-4 | .023 | |
| | 51-54 | .020 | |
| | 127-129 | | .007 |
| | 198-199 | | .007 |
| ym-22 | 11-14 | | .008 |
| | 181-183 | | .004 |
| | 328-329 | | .012 |
| ym-23 | 51-53 | .026 | |
| | 122-124 | | .008 |
| ym-24 | no standards | | |
| ym-25 | 16-18 | | .004 |
| | 57-59 | | .007 |
| | 101-104 | | .007 |
| | 156-159 | | .003 |
| ym-26 | 1-4 | .035 | |
| | 251-254 | | .007 |
| ym-27 | no standards | | |
| ym-28 | 7-9 | | |
| | 12-13 | | |
| | 77-79 | | |
| | 181-184 | | |
| | 227-229 | | .007 |

| hole # | interval (feet) | A (opt) | B (opt) |
|---|---|---|---|
| yk 29 | 27-29 | | .002 |
| | 101-104 | | .007 |
| | 96-99 | .025 | |
| | 171-174 | .035 | |
| ym-30 | 21-23 | .017 | |
| | 162-164 | | .008 |
| | 212-214 | .024 | |
| | 301-302 | | .004 |
| ym-31 | 7-9 | .024 | |
| | 147-149 | | .008 |
| | 313-314 | | .004 |
| ym-32 | 2-4 | .026 | |
| | 86-89 | .027 | |
| | 101-104 | | .008 |
| | 196-199 | | .008 |
| ym-33 | 17-19 | .022 | |
| | 121-123 | | .004 |
| | 251-253 | .025 | |
| | 377-379 | | .007 |
| ym-34 | 33-34 | .025 | |
| | 101-104 | | .009 |
| ym-35 | 31-34 | .022 | |
| | 91-94 | | ~~.004~~ |
| ym-36 | 91-94 | .017 | |
| | 161-164 | | .007 |
| ym-37 | 161-164 | | .008 |
| | 101-104 | .022 | |
| | 51-54 | | .008 |
| | 201-204 | .029 | |

| hole # | interval (feet) | A (opt) | B (opt) |
|---|---|---|---|
| ym-38 | 251-254 | | .007 |
| | 101-104 | .028 | |
| | 61-64 | | .008 |
| | 1-4 | .022 | |
| ym-39 | 301-304 | | .007 |
| | 191-194 | .021 | |
| | 101-104 | | .008 |
| | 12-14 | .022 | |
| ym-40 | 51-54 | .025 | |
| | 202-204 | .023 | |
| | 301-304 | | .008 |
| | 151-154 | | .008 |
| ym-41 | 251-254 | .022 | |
| | 131-133 | | .008 |
| | 17-19 | .030 | |
| | 362-364 | | .007 |
| ym-42 | 11-14 | .017 | |
| | 96-99 | | |
| | 183-184 | .025 | |
| | 291-293 | | .008 |
| ym-43 | 11-13 | .024 | |
| | 51-54 | | .007 |
| | 91-94 | .022 | |
| | 121-124 | | .007 |
| ym-44 | 7-9 | .022 | |
| | 103-104 | | .008 |
| | 197-199 | .025 | |
| | 251-254 | | .008 |

| hole # | interval (feet) | A (opt) | B (opt) |
|---|---|---|---|
| ym-45 | 21-24 | .022 | |
| | 92-93 | | .007 |
| ym-46 | 0-3 | .023 | |
| | 91-93 | | .008 |
| | 157-159 | .025 | |
| | 291-293 | | .007 |
| ym-47 | 1-3 | .028 | |
| | 101-103 | | .007 |
| | 201-203 | .027 | |
| | 301-303 | | |
| ym-48 | 17-19 | .025 | |
| | 121-123 | | .006 |
| | 207-209 | | .008 |
| ym-49 | 0-4 | .023 | |
| | 101-103 | | .008 |
| | 201-203 | .025 | |
| ym-50 | 1-3 | .023 | |
| | 71-73 | | .004 |
| ym-51 | 0-3 | .030 | |
| | 101-103 | | .008 |
| | 201-203 | .025 | |
| | 241-243 | | .008 |
| ym-52 | 43-47 | .019 | |
| | 101-103 | | .007 |
| | 171-173 | .022 | |
| ym-53 | 1-3 | .025 | |
| | 51-53 | | .008 |
| | 101-103 | | .008 |

| hole # | interval (feet) | A (opt) | B (opt) |
|---|---|---|---|
| ym 54 | 1-3 | .024 | |
| | 101-103 | | .008 |
| | 201-203 | .022 | |
| ym-55 | 1-3 | .022 | |
| | 101-103 | | .006 |
| | 201-203 | .022 | |
| ym-56 | 27-29 | .022 | |
| | 137-139 | | .022 |
| ym-57 | 21-23 | .021 | |
| | 91-93 | | .007 |
| ym-58 | 11-13 | .007 | |
| | 81-83 | | .007 |
| ym-59 | 7-9 | .004 | |
| | 81-83 | | .004 |
| | 186-187 | .004 | |
| ym-60 | 7-9 | .016 | |
| | 81-83 | | .004 |
| ym-61 | 21-23 | .004 | |
| | 121-123 | | .004 |
| | 191-193 | .016 | |
| | 221-223 | | .010 |
| ym-62 | 41-43 | .007 | |
| | 141-143 | | .007 |
| | 241-243 | .024 | |
| | 321-323 | | .007 |
| ym 63 | 11-13 | .033 | |
| | 111-113 | | .015 |
| | 211-213 | .020 | |

| hole # | interval (feet) | A (opt) | B (opt) | |
|---|---|---|---|---|
| ym-54 | 21-23 | .024 = 38 | | |
| | 101-103 | | .009 = 40 | |
| | 151-153 | .022 = 40 | | |
| | 181-183 | | .008 = 39 | |
| ym-65 | 11-13 | .021 = 39 | | |
| | 51-53 | | .020 = 40 | .00 |
| | 101-103 | .004 = 28 | | |
| ym-66 | 21-23 | .024 = 49 | | |
| | 41-43 | | .007 = 44 | |
| ym-67 | 21-23 | .007 = 3 | | |
| | 71-73 | | .007 = 44 | |
| ym-68 | 21-23 | .022 = 51 | | |
| | 71-73 | | .008 = 51 | |
| | 121-123 | | .007 = 50 | |
| ym-69 | ~~121-123~~ | ~~.016~~ | | |
| | 76-79 | | .010 = 53 | |
| | 171-174 | .025 = 44 | | |
| | 271-274 | | .007 = 15 | |
| | 371-374 | | .008 = 51 | |
| ym-70 | 21-24 | .021 = 40 | | |
| | 121-124 | | .006 = 46 | |
| | 161-164 | .022 = 46 | | |
| ym-71 | 21-23 | .022 = 51 | | |
| | 71-73 | | .005 = 38 | |
| | 121-123 | .022 = 42 | | |
| ym-72 | 21-24 | .025 = 42 | | |
| | 71-74 | | .007 = 43 | |
| | 101-104 | | .008 = 18 | |

| hole # | interval (feet) | A (opt) | B (opt) |
|---|---|---|---|
| ym-73 | 21-24 | .007 | .007 = 17 |
| | 71-74 | | .008 = 39 |
| | 101-104 | | |
| ym-74 | 21-24 | .015 = 5 | |
| | 71-74 | | .007 = 37 |
| | 121-124 | .022 = 43 | |
| ym-75 | 11-14 | .006 | .006 = 5 |
| | 101-104 | | .007 = 15 |
| | 151-154 | .022 = 43 | |
| | 201-204 | | .008 = 15 |
| ym-76 | 21-24 | .022 = 45 | |
| | 71-74 | | .008 = 16 |
| | 101-104 | | .007 = 16 |
| ym-77 | 131-134 | .005 | .005 = 11 |
| | 21-24 | .007 | .007 = 28 |
| | 71-74 | | .008 = 38 |
| ym-78 | 3-4 | .022 = 46 | |
| | 73-74 | | .008 = 44 |
| | 147-149 | .008 = 22 | |
| | 201-204 | | .009 = 50 |
| | 271-274 | | .008 = 32 |
| ym-79 | 1-4 | 023 = 43 | |
| | 61-64 | | .007 = 15 |
| | 101-104 | .022 = 40 | |
| | 181-184 | | .008 = 41 |
| ym-80 | 21-24 | .007 | .007 = 22 |
| | 101-104 | | .007 = 37 |
| | 201-204 | .021 = 21 | |
| | 291-294 | | .008 = 38 |

| hole # | interval (feet) | A (opt) | B (opt) |
|---|---|---|---|
| ym-81 | 18-19 | .020 = 5 | |
| | 91-92 | | .008 = 45 |
| | 136-138 | .023 = 34 | |
| ym-82 | 16-17 | .007 | .007 = 17 |
| | 91-93 | | .008 = 44 |
| | 141-143 | .007 | .008 = 4 |
| ym-83 | 7-9 | .022 = 17 | |
| | 77-79 | | .007 = 47 |
| | 207-209 | .022 = 23 | |
| | 237-239 | | .006 = 38 |
| ym-84 | 11-13 | .007 | .007 = 28 |
| | 91-93 | | .007 = 16 |
| | 121-123 | .023 = 44 | |
| | 191-193 | | .007 = 45 |
| ym-85 | 7-9 | | .008 = 41 |
| ym-86 | 1-3 | .007 | .007 = 11 |
| | 51-53 | ~~.006~~ | .006 = 32 |
| | 101-103 | .021 = 35 | |
| ym-87 | 3-4 | .016 = 48 | |
| | 103-104 | | .007 = 46 |
| | 203-204 | .014 = 40 | |
| | 303-304 | | .007 = 15 |
| ym-88 | 21-24 | .022 = 21 | |
| | 101-104 | | .007 = 15 |
| | 201-204 | .021 = 39 | |
| | 301-304 | | .007 = 42 |

| hole # | interval (feet) | A (opt) | B (opt) |
|---|---|---|---|
| m 89 | 1-4 | .005 | .005 = 10 |
| | 121-124 | .019 = 41 | |
| | 221-224 | .005 | .005 = 10 |
| | 321-324 | .021 = 43 | |
| m-90 | 21-24 | .016 = 61 | |
| | 121-124 | .019 = 38 | |
| | 221-224 | .016 = 31 | |
| m-91 | 21-24 | .021 = 14 | |
| | 121-124 | | .007 = 44 |
| m-92 | 31-34 | .022 = 46 | |
| | 131-134 | | .007 = 62 |
| m-93 | 21-24 | .008 | .008 = 30 |
| | 81-84 | | .006 = 46 |
| m-94 | 21-24 | .022 = 5 | |
| | 121-124 | | .009 = 16 |
| | 191-194 | .020 = 32 | |
| m-95 | 21-24 | .021 = 14 | |
| | 121-124 | | .007 = 47 |
| | 221-224 | .022 = 54 | |
| | 321-324 | | .006 = 42 |
| m-96 | 31-34 | .021 = 47 | |
| | 131-134 | .006 | .006 = 4 |
| | 497-499 | | .008 = 38 |
| | 531-534 | .021 = 14 | |

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

# REPORT OF ANALYSIS

JOB NO. TAJ 647
June 29, 1990
SIN#1-4 TO YAR43
PAGE 1 OF 1

ASARCO INCORPORATED
Attn: Mr. Mark Miller
Southwestern Exploration
P.O. Box 5747
Tucson, AZ 85703

ASARCO Incorporated
JUL 2 1990
SW Exploration

Analysis of 7 Rock Chip Sample

| ITEM | SAMPLE NO. | FIRE ASSAY Au* (ppm) | FIRE ASSAY Ag* (ppm) |
|---|---|---|---|
| 1 | SIN#1 | .006 | .6 |
| 2 | SIN#2 | .450 | .6 |
| 3 | SIN#3 | .370 | .4 |
| 4 | SIN#4 | .130 | .2 |
| 5 | BD#3-1 | .210 | .2 |
| 6 | BD#3-2 | .100 | .2 |
| 7 | YAR43 | .008 | .2 |

yarnell

*NOTE: Method of analysis by combination fire assay and atomic absorption.

cc: J.D. Sell (7/2/90)

William L. Lehmbeck
Manager

ASARCO Inc.

JUL 2 1990

SW Exploration

July 2, 1990

Mr. Christopher Moat, Chairman
NORGOLD RESOURCES (US) INC.
210-475 Howe Street
Vancouver, B. C. V6C-2B3
CANADA

Dear Mr. Moat:

RE: Yarnell Project

During the month of May 1990, Mr. J. D. Sell, Manager of Asarco's Southwestern Exploration Department, conducted a tour of the Yarnell property for Messrs. Steven Potter, Tench Page and Bob Schafer.

ASARCO Incorporated has spent an estimated $1,097,000.00 on the Yarnell Project from January 1989 through May 1990.

A detailed geologic review of computer generated plan and section maps continued during the month of June 1990.

S. L. Lakosky
Yarnell Project Manager

SLL/kh

bcc: TEScartaccini
RLBrown
WLKurtz
JDSell

CC: JDS, SL

620476

New York, July 5, 1990

MEMORANDUM FOR R. J. O'Keefe

Yarnell Project
Arizona

Please draw a check in favor of Norgold Resources Inc., for $10,000.00 to cover a payment due to Atchison, Topeka and Santa Fe Railway Company under an agreement under which that company has agreed to grant to the Yarnell Project an option to purchase certain land in the project area. If you will deliver the check to me, I will forward it to Norgold Resources, our partner in the Yarnell Project who made the deal between the project and the railway on behalf of the project.

R. L. Brown

RLB:mc

APPROVED
JUL 05 1990
CONTROLLER'S
CHECKED
AUTHORIZED

CHARGE 7810-007845

**ASARCO**

# ADVICE OF INTERCOMPANY TRANSACTIONS

COMPTROLLER DEPARTMENT

FORM AD 110

ISSUED BY: ONY

DATE: 07-06-90

THE FOLLOWING ENTRIES HAVE BEEN MADE IN OUR INTERCOMPANY ACCOUNT FOR:

(NAME & NUMBER) TUCSON (7845)

FOR ACCOUNTING MONTH OF: July

| ISSUING PLANT NO. | RECEIVING PLANT NO. | ISSUING PLANT'S ACCTG. MONTH | ISSUING PLANT'S ADVICE NUMBER | AMOUNT TO YOUR DEBIT/(CREDIT) | | DESCRIPTION |
|---|---|---|---|---|---|---|
| 7851 | 7845 | 07 | 03 | 10,000.00 | I | NORGOLD RESOURCES CO. V#070184 |
| | | | | | | 2600 / EA 0444-04 |
| | | | | | | C.L.S. JUL 16 1990 |
| | | | | | | 502-950 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

I DO NOT WRITE IN THIS COLUMN

MUST BE SUBMITTED ON A CURRENT BASIS TO RECEIVING PLANT.

APPROVED: [signature]

PRINTED IN U.S.A.

RECEIVING PLANT—1

LAW OFFICES
FENNEMORE CRAIG
A PROFESSIONAL CORPORATION

SUITE 2200
TWO NORTH CENTRAL AVENUE
PHOENIX, ARIZONA 85004-2390
(602) 257-8700

JDS

July 9, 1990

ASARCO Incorporated
180 Maiden Lane
New York, New York 10038

ATTN: Augustus B. Kinsolving, Esq.

JWJ
12194
OUR FILE NO.

PLEASE RETURN THIS PORTION OF STATEMENT WITH YOUR REMITTANCE

FEDERAL IDENTIFICATION NO. 86-0293128

Summary Sheet for Southwestern Mining Division

For legal services and disbursements rendered during the period from May 1, 1990 through May 31, 1990 per the attached schedule.

| | | |
|---|---|---|
| 202-524 | Arizona Surface Water Quality Standards (12194.066) | $10,602.70 |
| | Mission Expansion (12194.060) | 1,194.00 |
| | Mission Complex - Hazardous Waste Investigation (12194.074) | 1,138.50 |
| 202- | General Legislative (12194.045) | 992.28 |
| | Silver Bell Environmental Issues, General (12194.053) | 600.26 |
| 444-04 620-753 | Yarnell Gold Mine, Environmental Permitting (12194.052) | 517.50 |
| | Mission Landfill Compliance Issue/Environmental (12194.076) | 455.00 |
| 202- | General (12194.103) | 22.50 |
| | TOTAL FEES & DISBURSEMENTS SOUTHWESTERN MINING DIVISION | $15,522.74 |

COPY

# ASARCO

**Exploration Department**
Southwestern United States Division

July 9, 1990

Mr. Jerry L. Haggard
Apker, Apker, Haggard & Kurtz, P.C.
2111 East Highland Avenue, Suite 230
Phoenix, AZ 85016

Dear Mr. Haggard:

Enclosed are:

1. Map prepared by J.E. Shearer showing location of Y and Sun Claims. The only conflict if we were to extend the Pennsylvania west would be Y-6.

2. Map prepared by Mr. Gordon McLain showing how (in red) an amended claim would give a "best fit" situation. Point nos. 121, 203, 124, 133 and 117 are original corners as found on the ground.

3. Amended location notice for preliminary purposes.

Very truly yours,

William D. Gay

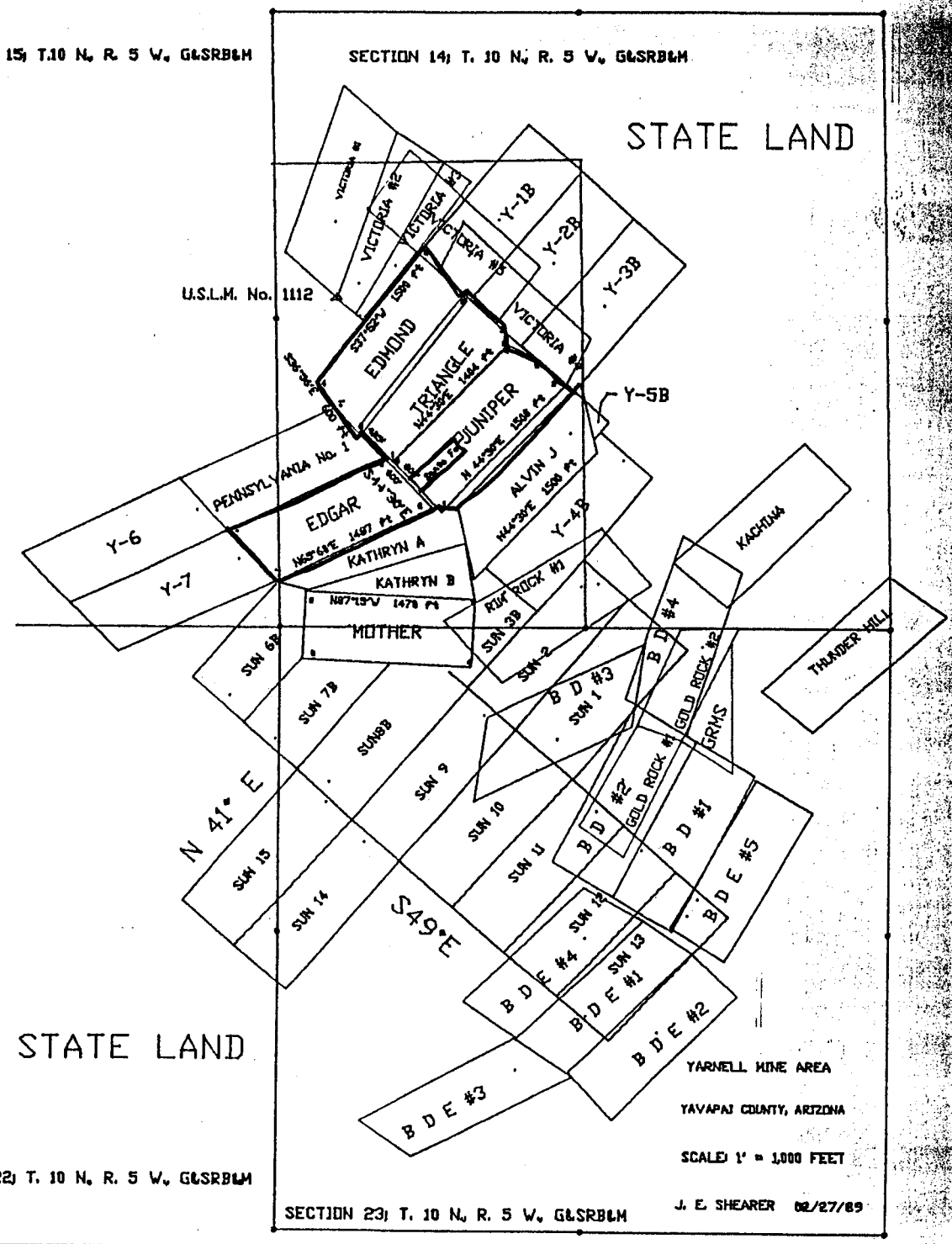
William D. Gay
Land Engineer

WDG:mek
Encs.

cc: J.D. Sell

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

REGISTERED GEOLOGIST
CERTIFICATE NO. 10843
JOSEPH EARL SHEARER
Date Signed 2-27-89
ARIZONA, U.S.A.




# ASARCO, INC.
# YARNELL PROJECT

AMENDED NOTICE OF LOCATION
(Lode Claim)

Notice is hereby given that ASARCO Incorporated, whose mailing address is P.O. Box 5747, Tucson, Arizona 85703, by its undersigned agent, makes this location of the PENNSYLVANIA No.1 lode mining claim, in the WEAVER Mining District, County of YAVAPAI, State of Arizona.

The claim is 1465 feet in length along the vein or deposit of mineral bearing rock in place and 619 feet in width (309.5 feet on either side of the center line of the claim), forming a claim in the shape of a parallelogram. The general course of said claim is ~~from~~ NE ~~to~~ _____.

This Notice is posted on the centerline of the claim which location monument is in Section 14, Township 10N, Range 5E, GSRB&M.

The location monument of said claim is located approx. N06°E 1297' from the SW corner of Section 14, Township 10N, Range 5E, GSRB&M, Arizona and said claim lies within the SW¼ SEC. 14 & SE¼ SEC. 15, T. 10S., R. 5E. GSRB&M.

The surface boundaries of the claim are described as follows: Beginning at the discovery monument and running thence N66°E to the center of the end line and the true point of beginning thence (clockwise) S43°E 309.5' to corner 1, thence S66°W 1465' to corner 2, thence N43°W 309.5' to center end line, thence N43°W 309.5' to corner 3, thence N66°E 1465' to corner 4, thence S43°E 309.5' to point of beginning.

There are seven substantial posts, projecting at least 4 feet above the surface of the ground, or stone monuments, at least 3 feet high, one for the location monument, one at each of the four corners and one at the center of each end line as prescribed by A.R.S. §27-204.

Located, dated and posted on the ground this ____ day of _____, 1990.

The original Notice of Location of this claim is recorded in the official records of _____ County, Arizona, as follows:

| Name of Claim | Recorded Book | Recorded Page | Recorded Date |
|---|---|---|---|
| PENNSYLVANIA No.1 | 1392 | 66 | 6-30-81 |

This amendment is made for purposes of more accurately describing the boundries hereof and correcting errors or ommissions (if any) contained in the original location notice. This amendment is made without waiver of the rights previously acquired under the location hereof. If for any reason it is determined that this notice is ineffective as an amendment of the location of this claim, the undersigned intends that this amendment shall serve as an original location of the area described herein as of the date of posting hereof.

ASARCO Incorporated

By _____
Agent

JDS

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

July 12, 1990

Mr. Michael D. Philpot
Chairman of the Board
Norgold Resources Inc.
210-475 Howe Street
Vancouver, B.C., V6C 2B3
Canada

Option Agreement
Harper/Hayt et al
Yarnell Project
Yavapai County, AZ

Dear Michael:

Your letter of June 29 has been received along with a copy of the Norgold check to Harper/Hayt for $2,500.00, also a copy of the Option Agreement.

Asarco SWED had received a copy of the agreement from Brian Edgar on December 18, 1989 which was placed in our Document Book (No. 90-5).

In reviewing the payments to Norgold the Accounting Department found that Tucson had been charged with the $2,500 US (Harper) and $6,250 CDN (legal fees) which had been approved in New York and paid by New York. The transfer to Tucson was made in February 1990, while the attached copy of the letter suggests it was paid to Norgold in January 1990.

As the Harper reimbursement must have been added to the same check to Norgold which included the legal fees, it would have been a check for some $8,000 US total (unless they paid you in $CDN?). Should you need further verification of the payment, I'll need to go through the New York Accounting Department for the voucher.

I do hope this clears up the payments, and I'm pleased that the Santa Fe microwave tower problem is about to be resolved.

Sincerely,

James D. Sell

James D. Sell

JDS:mek
Att.

cc: R.L. Brown, W.L. Kurtz, W.D. Gay, S.L. Lakosky, C.L. Snow

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

# NORGOLD RESOURCES INC.

U.S. OFFICES:
13935 Chamy Drive
Reno, Nevada
89511
(702) 851-3177
Fax: (702) 851-3177

HEAD OFFICE
210 - 475 Howe St
Vancouver, B.C
V6C 2B3
(604) 681-5566
Fax: (604) 687-87

January 15, 1990

7810 - 007845

approved for payment
R. L. Brown

ASARCO Inc.
180 Maiden Lane
New York, N.Y.
10038
U.S.A.

Attention: Mr. Richard Brown

62046

Dear Sirs:

Re: Norgold Resources Inc. and
Santa Fe Railway Company

Further to our recent meeting and telephone conversations, please be advised of the following:

1) Legal fees incurred by Norgold Resources Inc., with respect to bringing Santa Fe Railway Company to an agreement to move their telecommunications tower from Yarnell Mountain, amount to CDN $6,250 as per attached. Our verbal agreement called for ASARCO Inc. to assume these costs.

2) The option fee, paid to the Harpers to obtain the property on which the two telecommunication towers are to be relocated, amounted to U.S. $2,500. This sum is to be refunded to Norgold Resources Inc. as agreed.

In the cicumstances, we look forward to receipt of the above amounts at your earliest convenience.

Yours truly,

Christopher S. Moat
C.E.O. and Chairman

CSM/sjk

Enclosure

Yarnell Chg Tucson

RECEIVED
JAN 22 1990
EXPLORATION REPT.

**ASARCO**

**Southwestern Exploration Division**

JDS

July 12, 1990

RDH vs DDH

W. L. Kurtz

M.A. Miller's Comments
F.T. Graybeal's Memo
Yarnell Project
Yavapai County, Arizona

I forward Mr. Miller's comments without any further comment at this time.

James D. Sell

James D. Sell

JDS:mek
Att.

cc: F.T. Graybeal
M.A. Miller

**ASARCO**

Southwestern Exploration Division

July 6, 1990

J.D. Sell

F.T. Graybeal's Memo
Yarnell Project
Yavapai County, Arizona

Dr. Graybeal has raised some questions regarding the reverse circulation vs. diamond drilling study that I detailed in my memo of April 27, 1990 and you addressed in your memo of May 24, 1990. The stated premise of the diamond drilling program was as follows:

1. Obtain geologic information relative to ore controls and continuity of mineralization. This was accomplished since the drill core provided us a full section through the mineralized zone. The drilling confirmed geologic thoughts that were inferred from surface and underground exposures. The drill core also supports the possibility of a nugget effect in the orebody--a concept that has been voiced on a number of occasions. The idea of nugget effect was reinforced by the occurrence of visible gold in the drill core.

2. Twin a reverse circulation hole for assay confirmation. This was accomplished as explained below.

As my study of April 27, 1990 has indicated, there is sometimes considerable variation in individual assays. However, the interval when taken in total (which I feel is a much more realistic way of looking at the data) shows a very close correlation with the reverse circulation hole. The absolute difference between the two methods of drilling (based upon the assay results and assuming that assaying methodology is constant) is between 0 and 0.01 opt Au.

Several factors are probably responsible for the variation in the individual assay values between the two drilling techniques. These are

as follows:

1. Nugget effect - The occurrence of visible gold in the drill core strongly suggests that a nugget effect exists. This is also suggested in the high spikes seen in the RC assays within low grade intervals.

2. Irregular distribution of gold throughout the deposit- The variation in assays seen in the RC and diamond drilling and in all previous assaying, that we have done, points to an irregular distribution of gold. Best repeatability of assay values are obtained when the pulps are reassayed. Greater variance occurs when the rejects are resplit, reassayed, and then compared with the original values.

3. Original sample size of the reverse circulation hole vs. the diamond drill hole - The total amount of material that the rotary hole produces is ~200 pounds for a five foot sample. The total amount of material produced from an NC diamond drill hole is ~25 pounds for a five foot sample. The RC hole is divided into an 8:1 split with 7/8ths of the sample discarded. The remaining 1/8th is split into two equal fractions and then one half is sent for assay. The amount of material to the assay lab is ~12 pounds. The diamond drill core is sawed in half and one-half is sent for assay. The amount of material is ~12 pounds. While the final amount of material for assay is approximately the same, the beginning amount is considerably different with the RC hole providing at least ten times more sample than the diamond hole. Additionally, the RC hole sample has been mixed many times, within the drill hole, within the cyclone, and through the splitter, so the RC hole is more statistically correct as a homogenized sample than the diamond drill hole.

4. Sample lag or interval averaging - Dr. Graybeal seems to be confused by what I mean by this. What I am describing is the overlap that occurs from one interval to another as the sample is coming up the hole and is mixed in the cyclone. This is prevented in part by blowing the hole between each sample interval, but some lag still occurs.

I have calculated the mean and standard deviation on the net difference between the assays obtained through both drilling techniques (memo April 27, 1990). The mean ($\bar{X}$) is the arithmetic average of the assays

and the standard deviation (SD) is a measure of dispersion around the mean. Results are as follows:

| Hole Numbers | RC > DDH pos. net diff. | RC < DDH neg. net diff. |
|---|---|---|
| YM-8/YDDH-1 | $\bar{X}$ = .012<br>SD = .010 | $\bar{X}$ = .053<br>SD = .051 |
| YM-40/YDDH-2 | $\bar{X}$ = .025<br>SD = .030 | $\bar{X}$ = .021<br>SD = .042 |
| YM-75/YDDH-4 | $\bar{X}$ = .033<br>SD = .029 | $\bar{X}$ = .038<br>SD = .037 |

The large SD around the mean strongly suggests that the data cannot be compared in the fashion that you have done in your memo of 5/24/90. There is too much variation in the numbers to be compared on a straight line basis. This is why I feel that comparing the entire interval instead of individual assays is a better comparison of the drilling techniques and shows a closer correlation than you have suggested. I discussed this problem of correlation and repeatability of assays with Jerry Willis who is the Chief Geologist for Goldfields' Mesquite Mine in California. Since they are dealing with a deposit which is strongly fracture controlled I was curious as to whether they encountered the same problems on a mine scale that we see at Yarnell. They do have considerable variation in their blast holes on an individual basis, but correlation is much better when taken as a whole. He also attributes some of the variation in assays to the nugget effect. I think that Yarnell may have similar conditions, and it may be necessary to take replicate assays for increased confidence.

I agree with Dr. Graybeal's statement that "I might have expected that the rotary and diamond drill holes would check on an absolute basis, but the DDH holes would be more erratic due to the smaller sample size." I have already explained this case.

My statement that reverse circulation drilling was reporting the accurate values should probably be restated that the reverse circulation drilling is a more reliable method of evaluating the deposit for the above stated reasons. Yarnell does not suffer from a sampling problem such as occurred at the Cove and Rabbit Creek deposit where drilling technique severely biased the sampling.

In summary, I believe that there is good correlation between the two drilling techniques to have confidence in the values from the reverse circulation drilling which was one of the original premises for the

program. I do not think that the relationship that you have indicated exists. The assays received from the reverse circulation holes are reliable and I do not think that there is a consistent bias one way or another as Dr. Graybeal has suggested in his memo (May 31, 1990, page 2, paragraph 3).

MAM:mek

Mark A. Miller

cc: W.L. Kurtz

**ASARCO** Southwestern Exploration Division

JDS

July 12, 1990

M.A. Miller

Age Dating
Congress Mine Diorite
Yavapai County, Arizona

Your memo on the subject, dated July 9, 1990, will be of interest when Dewitt publishes his age dates.

As he has wandered around the area, I'm surprised he does not have a sample of the Yarnell diorite dikes as he has collected from all the other areas.

At Yarnell, you find little alteration in the N10°W trending diorite dike (your report in press), but do find quartz veins along the edges which have some gold. Thus you feel, but do not state, that the diorites are late in the sequence and may indeed be post-mineral. A bracket by age-dating the dike would be of interest when you can pin down its relationship to the Yarnell fault and the alteration-mineralization (including quartz veins, stockwork, and flooding quartz types).

Thus, if you wish to invite Dewitt to help himself to a diorite sample, then please do so.

How does Dewitt reconcile the thought that the alteration/gold mineralization is Mid-Tertiary while the Cretaceous age dikes cross-cut the alteration/gold mineralization and thus the dikes should be even younger Mid-Tertiary in age?

James D. Sell

JDS:mek

James D. Sell

cc: W.L. Kurtz

ASARCO

Southwestern Exploration Division

JDS

July 9, 1990

J.D. Sell

Age Dating
Congress Mine Diorite
Yavapai County, Arizona

I talked with Ed Dewitt of the USGS Denver regarding age dating of a diorite/gabbro dike that cross cuts the mineralization at the Congress Mine. Dewitt thinks that the dikes are Cretaceous in age. He has collected additional samples of other dikes in the area -- Alvarado, Octave, Beehive Mines, but the data is not yet available.

I think it would be worthwhile for Dewitt to do some work on the dikes at Yarnell. He feels that the dikes and sills are in some way related to the gold mineralization which he thinks is Mid-Tertiary in age. We might also suggest he look at the footwall of the mineralized zone for possible age relationships between the hanging wall and footwall granites. Dewitt said that the Yarnell granite has been dated at 1.4 billion years.

Mark A. Miller

MAM:mek

cc: W.L. Kurtz

July 13, 1979
To JAS from MAM

# YARNELL PROJECT

## ASSAY CHECKS

Triad vs Skyline

| SAMPLE | INTERVAL | TRIAD | SKYLINE | Diff | % |
|---|---|---|---|---|---|
| YM-10 | 165-170 | .036 | .040 | .004 | 10.0 |
| YM-10 | 190-195 | .017 | .020 | .003 | 15.0 |
| YM-10 | 210-215 | .034 | .032 | .002 | 5.9 |
| YM-11 | 190-195 | .045 | .055 | .010 | 18.2 |
| YM-11 | 200-205 | .018 | .024 | .006 | 25.0 |
| YM-11 | 230-235 | .121 | .170 | .049 | 28.8 |
| YM-12 | 125-130 | .094 | .105 | .011 | 10.5 |
| YM-12 | 170-175 | .031 | .026 | .005 | 16.1 |
| YM-12 | 225-230 | .015 | .030 | .015 | 50.0 |
| YM-13 | 185-190 | .023 | .012 | .011 | 47.8 |
| YM-13 | 205-210 | .019 | <.002 | .017 | 89.5 |
| YM-14 | 20-25 | .013 | .014 | .001 | 7.1 |
| YM-14 | 45-50 | .033 | .022 | .011 | 33.3 |
| YM-14 | 60-65 | .072 | .075 | .003 | 4.0 |
| YM-14 | 70-75 | .101 | .110 | .009 | 8.2 |
| YM-15 | 140-145 | .132 | .065 | .067 | 50.8 |
| YM-15 | 190-195 | .017 | .010 | .007 | 41.2 |
| YM-15 | 255-260 | .059 | .060 | .001 | 1.7 |
| YM-16 | 30-35 | .019 | .020 | .001 | 5.0 |
| YM-16 | 50-55 | .046 | .055 | .009 | 16.4 |
| YM-16 | 70-75 | .039 | .042 | .003 | 7.1 |
| YM-17 | 260-265 | .018 | .046 | .028 | 60.9 |
| YM-17 | 285-290 | .076 | .050 | .026 | 34.2 |
| YM-17 | 310-315 | .114 | .125 | .011 | 8.8 |
| YM-18 | 55-60 | .021 | .028 | .007 | 25.0 |
| YM-18 | 85-90 | .011 | .006 | .005 | 45.5 |
| YM-18 | 105-110 | .035 | .036 | .001 | 2.8 |
| YM-18 | 125-130 | .297 | .290 | .007 | 2.4 |
| YM-19 | 35-40 | .062 | .070 | .008 | 11.4 |
| YM-19 | 75-80 | .013 | .012 | .001 | 7.7 |
| YM-19 | 210-215 | .053 | .055 | .002 | 3.6 |
| YM-19 | 230-235 | .083 | .070 | .013 | 15.7 |

| SAMPLE | INTERVAL | TRIAD | SKYLINE | Diff | % |
|---|---|---|---|---|---|
| YM-20 | 5-10 | .011 | .010 | .001 | 9.1 |
| YM-20 | 25-30 | .331 | .295 | .036 | 10.9 |
| YM-21 | 30-35 | .033 | .040 | .007 | 17.5 |
| YM-21 | 45-50 | .014 | .020 | .006 | 30.0 |
| YM-21 | 85-90 | .032 | .026 | .006 | 18.8 |
| YM-22 | 215-220 | .025 | .014 | .011 | 44.0 |
| YM-22 | 235-240 | .007 | <.002 | .005 | 71.4 |
| YM-22 | 270-275 | .032 | .040 | .008 | 20.0 |
| YM-23 | 40-45 | .116 | .115 | .001 | 0.9 |
| YM-23 | 60-65 | .026 | .022 | .004 | 15.4 |
| YM-23 | 100-105 | .061 | .075 | .014 | 18.7 |
| YM-23 | 115-120 | .036 | .030 | .006 | 16.7 |
| YM-24 | 75-80 | .229 | .270 | .041 | 15.2 |
| YM-24 | 95-100 | .095 | .105 | .010 | 9.5 |
| YM-24 | 100-105 | .038 | .060 | .022 | 36.7 |
| YM-25 | 65-70 | .111 | .085 | .026 | 23.4 |
| YM-25 | 70-75 | .078 | .165 | .087 | 52.7 |
| YM-25 | 80-85 | .023 | .008 | .015 | 65.2 |
| YM-26 | 205-210 | .061 | .065 | .004 | 6.2 |
| YM-26 | 230-235 | .012 | .014 | .002 | 14.3 |
| YM-26 | 260-265 | .149 | .240 | .091 | 37.9 |
| YM-26 | 265-270 | .099 | .130 | .031 | 23.8 |
| YM-27 | 70-75 | .023 | .030 | .007 | 23.3 |
| YM-27 | 85-90 | .012 | .010 | .002 | 16.7 |
| YM-27 | 120-125 | .042 | .034 | .008 | 19.0 |
| YM-27 | 240-245 | .032 | .030 | .002 | 6.3 |
| YM-28 | 130-135 | .004 | <.002 | .002 | 50.0 |
| YM-28 | 140-145 | .031 | .030 | .001 | 3.2 |
| YM-28 | 155-160 | .036 | .016 | .020 | 55.6 |
| YM-28 | 195-200 | .025 | <.002 | .023 | 92.0 |
| YM-29 | 200-205 | .009 | .010 | .001 | 10.0 |
| YM-29 | 220-225 | .046 | .050 | .004 | 8.0 |
| YM-29 | 235-240 | .007 | <.002 | .005 | 71.4 |
| YM-30 | 180-185 | .019 | .020 | .001 | 5.0 |
| YM-30 | 195-200 | .011 | .010 | .001 | 9.1 |
| YM-30 | 230-235 | .093 | .016 | .077 | 82.8 |
| YM-30 | 240-245 | .027 | .038 | .011 | 28.9 |

| SAMPLE | INTERVAL | TRIAD | SKYLINE | Diff | % |
|---|---|---|---|---|---|
| YM-31 | 365-370 | .093 | .095 | .002 | 2.1 |
| YM-31 | 375-380 | .044 | .044 | ~~0~~ | ~~0~~ |
| YM-31 | 380-385 | .015 | .016 | .001 | 6.3 |
| YM-32 | 65-70 | .013 | .012 | .001 | 7.7 |
| YM-32 | 75-80 | .010 | .020 | .010 | 50.0 |
| YM-32 | 190-195 | .027 | .032 | .005 | 15.6 |

75

J. E. A. M.
SEP 21 1970

PIONEERING AND PLACING Pipe on a 30 percent slope can always present a problem. This is a situation Tanner Brothers Contracting Co. has had to face at their 2.4 mile grade and drain job on the slopes of Yarnell Hill. The work begins about four miles northeast of Congress Junction and extends northeasterly over US Route 89.

General Superintendent Kay Rogers called the project, "One of the roughest I've ever been on." He said, "When you have to do pioneering at a 30 percent differential, the job becomes almost impossible." He added, "You can wind up moving the same material three and four times. You get to know it pretty darn well."

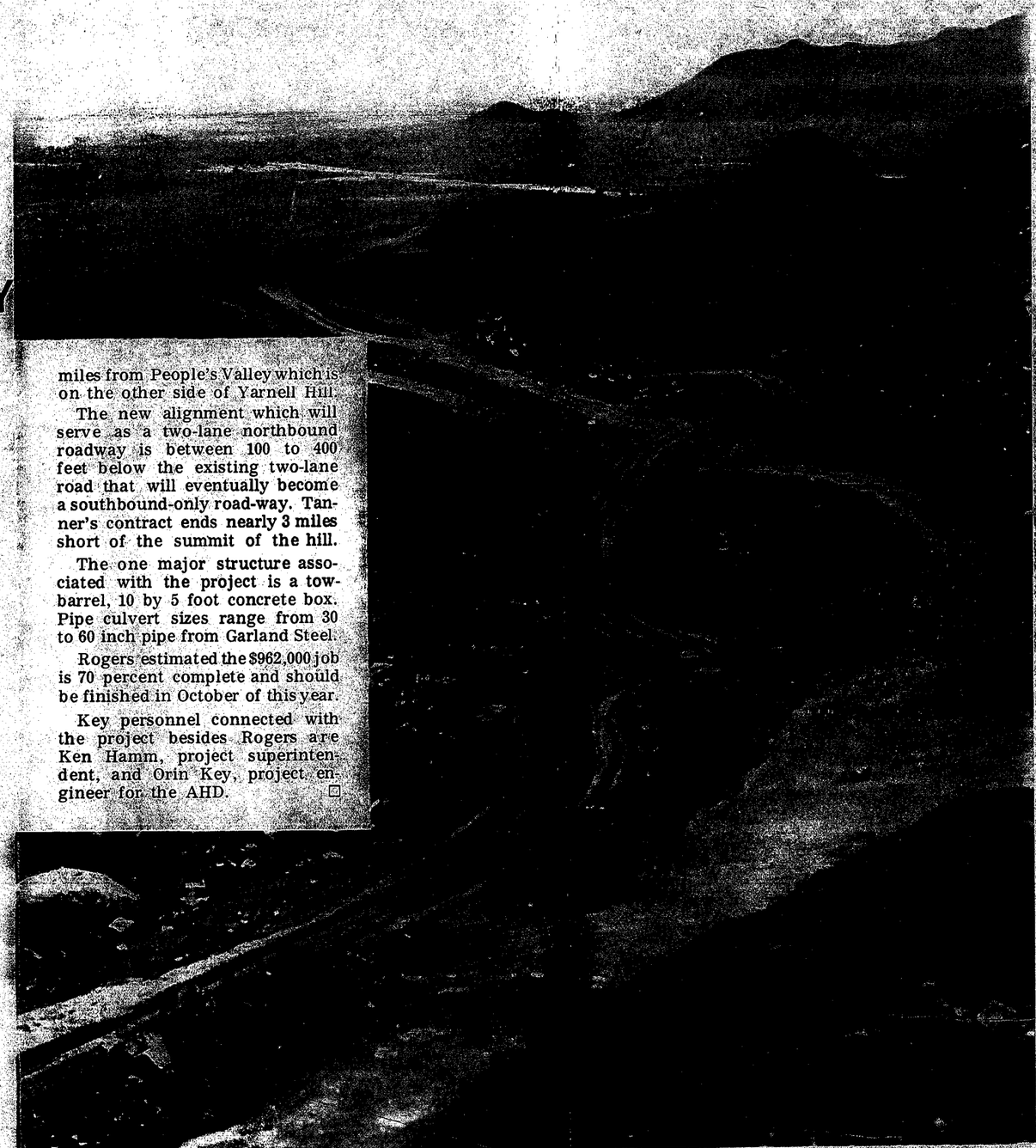
Moving water into the area has been another of Tanner's headaches. Water has been piped 12 miles from People's Valley which is on the other side of Yarnell Hill.

The new alignment which will serve as a two-lane northbound roadway is between 100 to 400 feet below the existing two-lane road that will eventually become a southbound-only road-way. Tanner's contract ends nearly 3 miles short of the summit of the hill.

The one major structure associated with the project is a tow-barrel, 10 by 5 foot concrete box. Pipe culvert sizes range from 30 to 60 inch pipe from Garland Steel.

Rogers estimated the $962,000 job is 70 percent complete and should be finished in October of this year.

Key personnel connected with the project besides Rogers are Ken Hamm, project superintendent, and Orin Key, project engineer for the AHD. □







via SAA → MAM 7-18-90

✓ copy fig 3, p. 44-47
fig 14 / p. 101 /
✓ copy Brachiopod with GP-Slate 1 p. 67-68-69
✓ fig 5 p 77
✓ fig 6 p. 78
✓ fig 13 p 100
✓ fig 14 p. 101
✓ fig 15 p 103
✓ fig 16 p 107
✓ fig 17 p 109
✓ Group 4 p. 110 - ~~#1~~
Group 4, p 113-114
Table 1 p. 115 - ~~#6~~
Table 2 p 116 - 117-118-119
Conclusions - Ref. p. 143-144-145-146-147,

✓ DeWitt paper
p. 149 — 163

✓
✓ fig 6 - p. 44

in Jenney, J.P., and Reynolds, S.J., 1989, Geological Evolution of Arizona: Tucson, Arizona Geological Society Digest 17, p.

p. 110 ~~Bang~~. ~~St~~ V. Anderson, Phillip, 1989, Stratigraphic Framework, Volcanic-Plutonic Evolution, and Vertical Deformation of the Proterozoic Volcanic ~~Belt~~ of Central Arizona p. 57-147 in

p. 110. Group 4: Late (Late-Tectonic) Porphyritic Monzogranite-Granite Plutons and Batholiths.

Yarnell Granodiorite (new formal name; P. Anderson, 1956). The Yarnell Granodiorite is named for exposures of (weakly) foliated, coarse-grained porphyritic granodiorite to monzogranite just north of Yarnell. More coarsely porphyritic monzogranite comprises a vast batholith in the Weaver and the Wolf Creek Mountains to the southwest (fig. 14), but this batholith is largely unstudied and may involve 1400-Ma plutonic rocks. The Yarnell Granodiorite is therefore discussed separately from the batholith, even though their chemistries are similar (fig. 17). The Yarnell Granodiorite follows the northwest edge of the Stanton-Octave metavolcanic-metasedimentary screen to as far north as Wilhoit (fig. 14), where dikes of unfoliated Yarnell Granodiorite intrude foliated granodiorite of the Wilhoit batholith.

The Yarnell Granodiorite is distinctively coarse-grained and weakly foliated with

large pinkish-tan K-feldspar phenocrysts in an equigranular matrix with biotite, plagioclase, uncommon hornblende, and abundant sphene. Macroscopically it resembles no other rock in the Prescott region; it is similar to 1400-Ma granite in phenocryst habit, but the main Yarnell body is deformed and not a 1400-Ma body. The main K-feldspar is twinned microcline, a mineral not found in most preceding plutonic rocks. Where the rock is foliated, oligoclase, perthitic microcline, quartz, and biotite are recrystallized to fine aggregates of sericite, quartz, feldspar, biotite, chlorite, and magnetite. Yarnell Granodiorite is diagnostically rich in sphene.

Chemically the Yarnell body is a metaluminous high-K, calc-alkaline, high-Fe-Ti and high-total-alkali rock of monzogranite to granodiorite composition. It appears to have been derived by fractional crystallization that started in the plagioclase-hornblende field, but it largely crystallized before reaching the eutectic, because microcline and quartz are interstitial to orthoclase and plagioclase. In biotite granodiorite compositions, hornblende survives as only a partially reacted constituent, but in porphyritic monzogranite compositions it is almost totally reacted to biotite, chlorite, and magnetite.

Table 2. (cont.)

| | Rock Unit, Sample Number | | | | | | |
|---|---|---|---|---|---|---|---|
| | Granite of Rich Hill | | Granodiorite of Yarnell | | | | |
| | 11-25-84-2 | 11-25-84-3A | 11-26-84-1 | 11-24-84-2 | 11-24-84-1 | | |
| | 69 (H) | 70 (H) | 72 (Y) | 73 (Y) | 74 (Y) | JJM HW | JJM FW |
| $SiO_2$ | 74.5 | 74.5 | 67.4 | 66.3 | 65.1 | 70.0 | 69.8 |
| $Al_2O_3$ | 13.1 | 13.8 | 14.5 | 14.1 | 14.3 | 14.3 | 14.4 |
| $Fe_tO_3$ | 1.50 | 1.64 | 4.98 | 5.45 | 6.65 | 3.2 $Fe_2O_3$ | 4.3 |
| MgO | 0.28 | 0.31 | 1.17 | 1.22 | 1.52 | 1.0 | 1.1 |
| CaO | 0.66 | 1.85 | 2.57 | 2.84 | 3.43 | 2.6 | 2.3 |
| $Na_2O$ | 3.43 | 3.85 | 3.08 | 3.10 | 3.14 | 3.2 | 3.1 |
| $K_2O$ | 5.12 | 2.47 | 4.18 | 4.33 | 3.78 | 4.1 | 3.9 |
| LOI | 0.48 | 0.86 | 0.55 | 0.76 | 0.65 | | |
| $TiO_2$ | 0.19 | 0.12 | 0.80 | 0.79 | 1.02 | .70 | .85 |
| $P_2O_5$ | 0.05 | 0.02 | 0.27 | 0.34 | 0.39 | .45 | .55 |
| MnO | 0.04 | 0.06 | 0.12 | 0.11 | 0.13 | .11 | .13 |
| Total | 99.36 | 99.49 | 99.62 | 99.34 | 100.11 | | |
| Ba | 1167 | 1257 | 1129 | 1084 | 1034 | | |
| Rb | 141 | 39 | 143 | 145 | 117 | | |
| Sr | 276 | 394 | 276 | 248 | 296 | | |
| Y | 14 | 9 | 56 | 35 | 53 | | |
| Zr | 172 | 87 | 289 | 289 | 276 | | |
| Nb | 34 | 17 | 31 | 28 | 30 | | |
| La | 94 | 34 | 71 | 80 | 69 | | |
| Ce | 148 | 49 | 157 | 166 | 142 | | |

FeO
1.40 0.65

Converting FeO to $Fe_2O_3$ and adding $Fe_2O_3$ giving $Fe_tO_3$:

HW FW
4.7 5.0

Table 3. Minor-element concentrations of 1700-1750-Ma plutonic rocks, north-central Arizona. [Sample numbers as in fig. 1; [0.02], detection limits for elements listed; --, element not detected; analyzed by X-ray fluorescence on Kevex detector by Ed DeWitt and Ross Yeoman; plotting symbols are those in figs. 2-8]

| Rock Unit | Plotting symbol | Sample No. | FeO (%) [0.02] | Ba (ppm) [6] | Rb (ppm) [6] | Sr (ppm) [6] | Y (ppm) [5] | Zr (ppm) [4] | Nb (ppm) [3] | La (ppm) [6] | Ce (ppm) [7] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Prescott Granodiorite | P | 4 | 2.6 | 1320 | 53 | 785 | 10 | 163 | 17 | 49 | 80 |
| Prescott Granodiorite | P | 5 | 1.6 | 1107 | 95 | 417 | 6 | 123 | 16 | 40 | 67 |
| Government Cyn. Gd. | V | 13 | 5.0 | 869 | 43 | 846 | 11 | 116 | 14 | 52 | 99 |
| Government Cyn. Gd. | V | 16 | 2.7 | 971 | 37 | 893 | 8 | 101 | 14 | 48 | 74 |
| Tonalite of Cherry | C | 20 | 3.8 | 630 | 31 | 676 | 6 | 43 | 6 | 22 | 32 |
| Tonalite of Cherry | C | 23 | 3.3 | 540 | 29 | 649 | 5 | 47 | 9 | 21 | 29 |
| Tonalite of Cherry | C | 24 | 4.1 | 661 | 56 | 651 | -- | 50 | 9 | 24 | 33 |
| Tonalite of Cherry | C | 25 | 4.4 | 545 | 50 | 637 | 9 | 94 | 15 | 30 | 66 |
| Crooks Cyn. Granodiorite | R | 34 | 2.1 | 1087 | 77 | 134 | 36 | 201 | 24 | 75 | 151 |
| Brady Butte Granodiorite | B | 40 | 2.3 | 1289 | 52 | 399 | 11 | 141 | 20 | 52 | 80 |
| Brady Butte Granodiorite | B | 44 | 2.3 | 1041 | 61 | 316 | 21 | 123 | 16 | 49 | 84 |
| Granodiorite of Minnehaha | M | 46 | 4.9 | 1024 | 49 | 214 | 19 | 110 | 16 | 30 | 54 |
| Gd. of Big Bug Creek | U | 49 | 3.0 | 385 | 4 | 201 | 42 | 135 | 13 | 29 | 53 |
| Badger Spring Gd. | E | 58 | 1.9 | 799 | 13 | 185 | 18 | 104 | 18 | 28 | 46 |
| Crazy Basin Qtz. Monz. | Q | 64 | 1.4 | 879 | 157 | 174 | 11 | 128 | 20 | 75 | 135 |
| Crazy Basin Qtz. Monz. | Q | 65 | 1.2 | 1065 | 153 | 186 | 6 | 126 | 20 | 58 | 111 |
| Granite of Rich Hill | H | 71 | 0.5 | 577 | 87 | 63 | 19 | 37 | 21 | 22 | 40 |

Mel:

Please copy:

p. 44

p. 66-67-68-69

p. 77-78

p. 100-101

p. 103

p. 107

p. 109-110-

p. 113-114-115-116-117-118-119

p. 143-144-145-146-147

p. 149 thru 163.

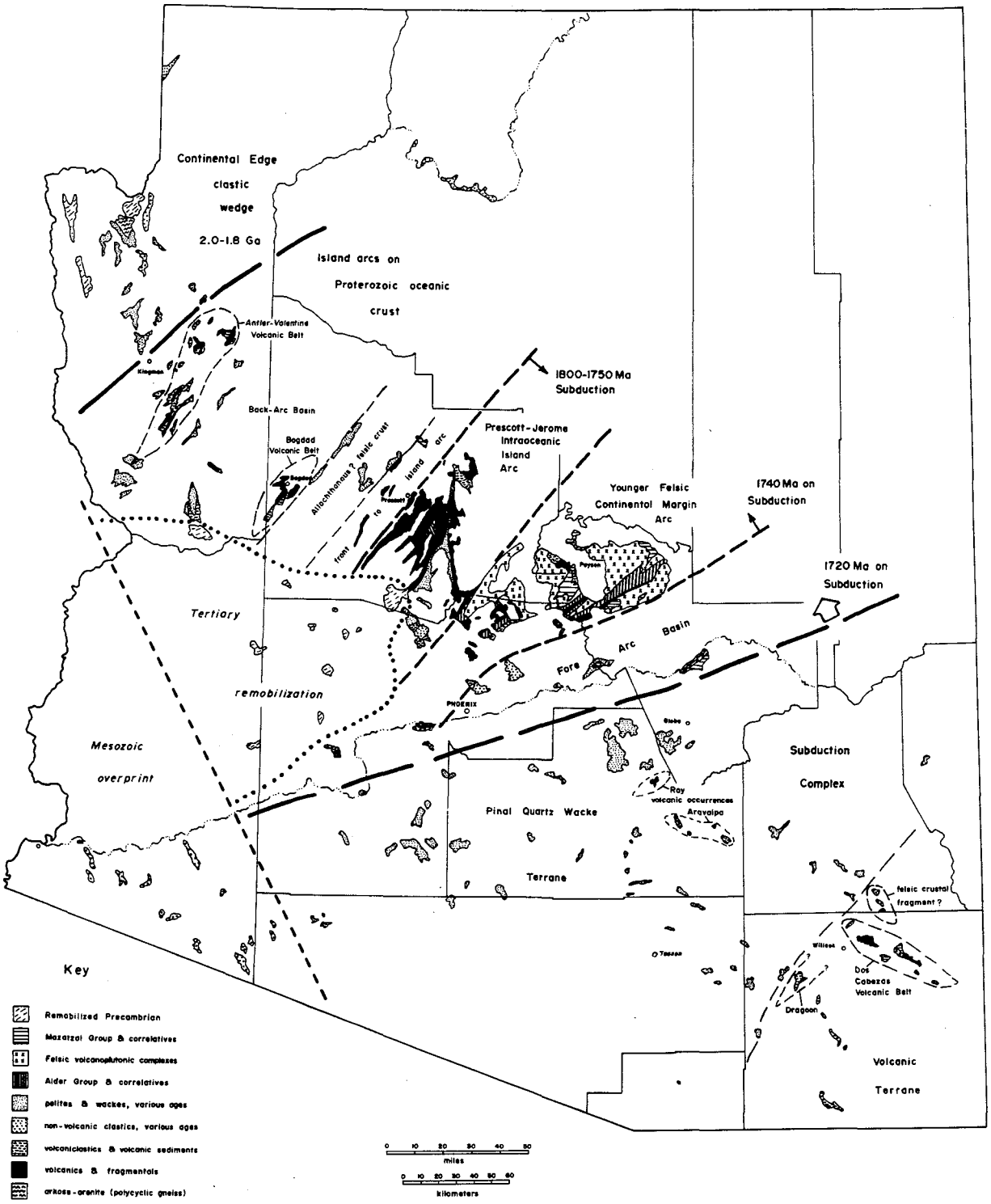
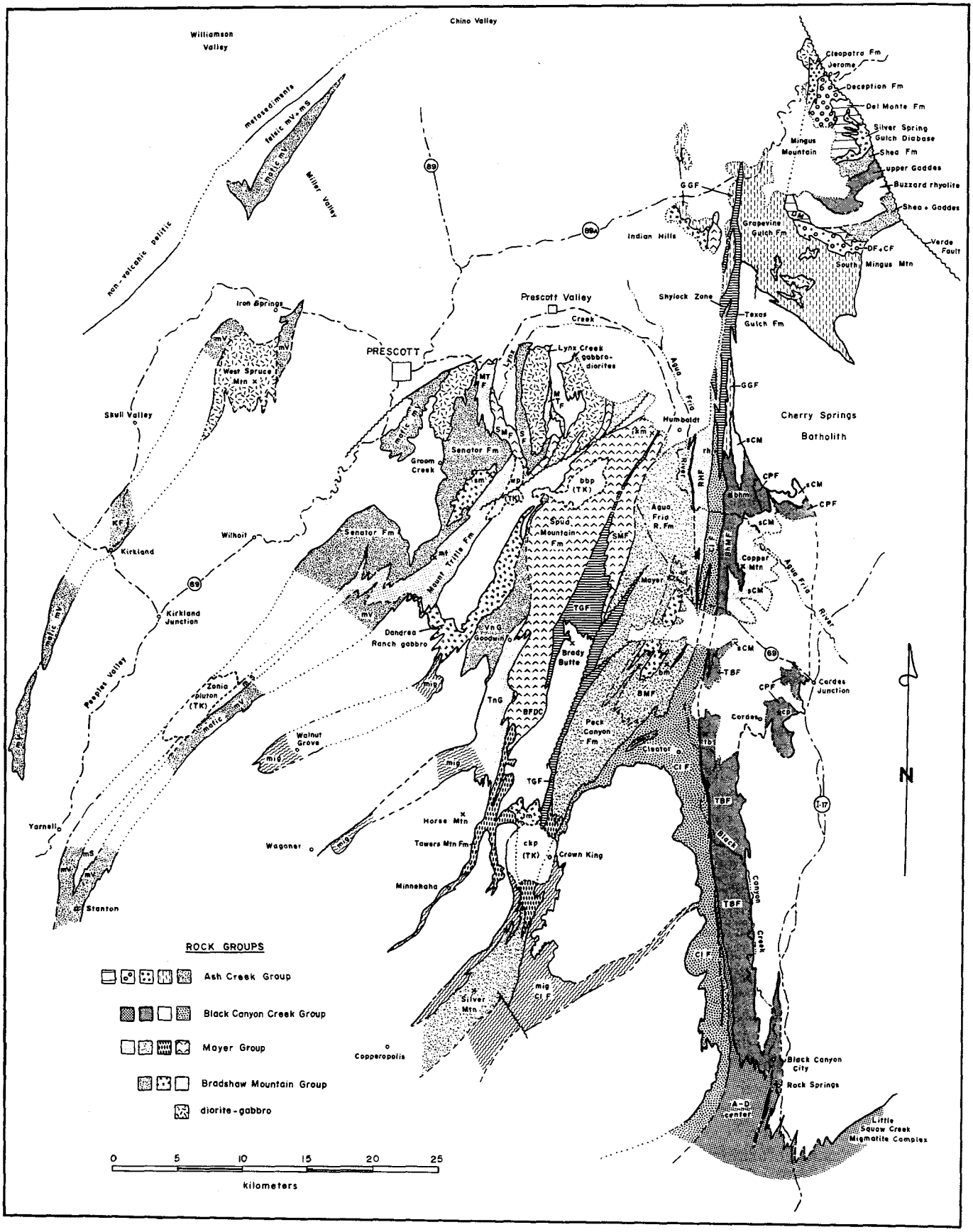



Figure 6. Proterozoic plate tectonic evolution of Arizona depicted from a map perspective. The base is the same as figure 3, but different trench positions for the southeast- and northwest-dipping subduction events are shown for the age ranges listed. The arrows point down the dip of the subducted paleo-oceanic slab for each subduction event. Proterozoic oceanic basement lay between the two heavy long-dashed lines under the volcanic belts of central and northwest Arizona, but the nature of basement on either side of this central region is unknown. 1800- to 1750-Ma southeast-dipping subduction gave rise to volcanics that formed the Prescott-Jerome intraoceanic island arc and parts of the eastern Central Volcanic Belt. From 1740 Ma on, northwest-dipping subduction produced plutonism throughout the Prescott-Jerome arc and all contemporaneous and younger volcanism in the eastern part of the Central Volcanic Belt, as well as other parts of southeast Arizona. The trench axis stepped southeast in discrete events, one recognizable where shown at about 1720 Ma or earlier, another possible transitory position is located near Willcox, and the final post-1695-Ma trench axis for northwest dipping subduction lies out of Arizona.


Williamson Valley
Chino Valley
metasediments
felsic mV+mS
mafic mV
Miller Valley
non-volcanic pelitic
Cleopatra Fm
Jerome
Deception Fm
Del Monte Fm
Silver Spring
Gulch Diabase
Shea Fm
Mingus Mountain
Upper Gaddes
Buzzard rhyolite
Shea + Gaddes
Verde Fault
GGF
Grapevine Gulch Fm
DF+CF
South Mingus Mtn
Indian Hills
Prescott Valley
Shylock Zone
Texas Gulch Fm
Iron Springs
PRESCOTT
West Spruce Mtn
Lynx Creek gabbro-diorites
Lynx Creek
Agua Fria
Humboldt
Cherry Springs Batholith
Skull Valley
Groom Creek
Senator Fm
bbp (TK)
Agua Fria R. Fm
Spud Mountain Fm
Kirkland
Wilhoit
Mount Trilla Fm
Copper Mtn
Mayer
Kirkland Junction
Dandrea Ranch gabbro
Brady Butte
Cordes Junction
Peeples Valley
Zonia pluton (TK)
TnG
BFDC
Pack Canyon Fm
Cleator
Cordes
Walnut Grove
Horse Mtn
Yarnell
Wagoner
Towers Mtn Fm
ckp (TK)
Crown King
Minnehaha
Stanton
Black Canyon Canyon Creek
Silver Mtn
Copperopolis
Black Canyon City
Rock Springs
A-D center
Little Squaw Creek migmatite Complex
ROCK GROUPS
Ash Creek Group
Black Canyon Creek Group
Mayer Group
Bradshaw Mountain Group
diorite-gabbro
0 5 10 15 20 25
kilometers
N

**Diorite-Gabbro Bodies**

A key feature of the Grapevine Gulch Formation is its self-contained gabbro-diorite bodies, which pervade the strata at many localities (especially southern Mingus Mountain), but are nowhere found intruding adjacent, older strata. Intrusion of the gabbro-diorites seems to have occurred just after deposition and possibly before consolidation of Grapevine Gulch strata and was apparently localized to the Grapevine Gulch depositional basin.

**Younger Fragmentals**

On the southeast end of the Jerome belt are thick felsic fragmentals unlike any other units in the belt. Polymictic dacitic agglomerate, limestone-fragment conglomerate, and other types of recycled rocks are overlain by a chaotic array of oxidized rhyodacite agglomerate and breccia. These shallow subaqueous and subaerial deposits are now known to be stratigraphically younger than all foregoing deeper submarine deposits in the Jerome belt. C. A. Anderson and Creasey (1958) included the lower dacitic and upper rhyodacitic parts of this young fragmental pile into their oldest "Gaddes basalt" and "Buzzard rhyolite," respectively. Although these young rocks correlate to the youngest intermediate-felsic fragmentals of the Black Canyon Creek Group in the Prescott volcanic belt (fig. 4), they are retained as upper Gaddes and Buzzard units (fig. 4) until future work resolves their complex stratigraphies.

**Texas Gulch Formation**

In the northern Shylock zone is a distinctive sequence of purple slate, siltstone, wacke, conglomerate, and tuff that is younger than all preceding strata of the Jerome volcanic belt: where quartz diorite of the Cherry Springs batholith intrudes formative volcaniclastic (Grapevine Gulch) strata, the purple slate sequence rests in depositional unconformity upon the quartz diorite (P. Anderson, 1986). C. A. Anderson and Creasey (1958) named this sequence **Texas Gulch Formation,** but evidently did not perceive the significance of its unconformable relation on the quartz diorite. The Texas Gulch Formation is now known to be a time-stratigraphically unique formation that postdates all other strata in the Jerome volcanic belt by an event of plutonism, uplift, and unroofing of the Cherry Springs batholith. The Texas Gulch Formation was first included in the Ash Creek Group, was later recognized as younger (C. A. Anderson and others, 1971), and is now not considered to be part of that group (fig. 4 and P. Anderson, 1986).

## STRATIGRAPHY OF THE PRESCOTT VOLCANIC BELT

Previous studies suggested little if any correlation between volcanic stratigraphies of the Prescott and Jerome belts. The above summary shows five major depositional stages in evolution of the Jerome belt, and, as seven similar stages in the Prescott belt's evolution unfold below, close links between the two belts will become clear (fig. 4). The seven depositional stages of the Prescott belt can be translated directly into one or more lithostratigraphically unique formations that were deposited during each stage. Each formation belongs to one of three major rock-stratigraphic groups: rocks of stages 1 and 2 belong primarily to the **Bradshaw Mountains Group,** rocks of stage 3 and stage 4 make up the **Mayer Group,** and rocks of stage 5 and stage 6 compose the **Black Canyon Creek Group.**

### BRADSHAW MOUNTAINS GROUP—STAGE 1

The oldest stage 1 rocks in the Prescott volcanic belt lie in the northern Bradshaw Mountains south of Prescott and comprise a thick sequence of submarine aphanitic basalt flows, pillow lavas, basaltic breccia, agglomerate, and tuff, with minor intercalated, altered rhyodacite flows, dikes, and tuffs. The basalts are tholeiitic, commonly spilitic, the rhyodacites are keratophyric, and lateral facies equivalents in deep-water pelagic settings comprise a suite of tholeiitic basalt flows, agglomerate, tuff, graywacke, and ribbon chert. This deep-water oceanic suite was once extensive throughout the region west and southwest of Prescott, but now occurs only as mafic volcanic screens within and between granodiorite plutons and batholiths that subsequently pervaded the area.

Farther south in the Bradshaw Mountains, near Goodwin, an identical sequence of tholeiitic aphanitic basalt flows, pillowed units, and mafic tuffs is separated from northern exposures by several plutons, but shows all evidence of being stratigraphically equivalent to the main stage 1 tholeiitic basalt exposures to the north (fig. 3). The

Figure 3 (facing page). Geologic map of major stratigraphic sequences in the Prescott-Jerome volcanic belts. Areas between the major units are occupied by Proterozoic plutonic rocks (heavy solid lines), discussed in Part 3, or post-Proterozoic cover (thin dotted lines). Some smaller areas of cover within the major units are omitted for simplicity. The following abbreviations are used. **Ash Creek Group:** CF = Cleopatra Formation; DF = Deception Formation; DMF = Del Monte Formation; GGF = Grapevine Gulch Formation; TGF = Texas Gulch Formation. **Bradshaw Mountains Group:** SF = Senator Formation. MTF = Mount Tritle Formation; VnG = volcanics (Senator Formation) near Goodwin; TnG = tuffs (Mount Tritle Formation) near Goodwin. KF = Kirkland Formation. **Mayer Group:** RHF = Round Hill Formation; BMF = Bluebell Mine Formation; SMF = Spud Mountain Formation. **Black Canyon Creek Group:** BhMF = Binghampton mine facies; CPF = Cordes Peak facies; TBF = Townsend Butte facies. sCM = subaerial rocks of Copper Mountain volcanic center; Cl F = Cleator Formation. **Other rock types:** A-D center = Andesite-dacite center near Black Canyon City; mig = migmatite and migmatitic varieties of other formations; mV = metavolcanic rocks; mS = metasedimentary rocks. **Laramide (TK) Plutons:** ckp = Crown King pluton; bbp = Big Bug pluton; wp = Walker pluton. **Place Names:** BFDC = Battle Flat dacite center; bm = Bluebell mine; bhm = Binghampton mine; cp = Cordes Peak; ikm = Iron King mine; mt = Mount Tritle; mu = Mount Union; rh = Round Hill; sm = Spruce Mountain; tb = Townsend Butte; tm = Towers Mountain.

most significant features of the earliest tholeiitic basaltic volcanism are its primitive, magnesian, bimodal character, very deep water setting, and lack of differentiation.

**New Stratigraphy**

The stratigraphically oldest stage 1 mafic volcanics of the Prescott belt, including tholeiitic basalt flows, pillow lavas, breccia, tuff, agglomerate, and correlatives in the northern Bradshaw Mountains and near Goodwin, are newly and formally named the **Senator Formation** for their type section along the Senator road near the Senator mine south of Prescott. To the southwest away from the main Senator volcanic center of the northern Bradshaw Mountains, other volcanic strata interface with the distinctive Senator strata and may, in the future, warrant recognition as separate formations.

**Previous Stratigraphy**

The earliest volcanic units of the Prescott belt were not recognized as a time-stratigraphically unique igneous suite, and were placed in different map units depending on location: (1) the main northern exposures, together with younger rock units, were mapped as "Green Gulch volcanics," which is no longer a viable formation (P. Anderson, 1986); and (2) the southern exposures near Goodwin were included in the "Spud Mountain volcanics" map unit because they lie south of C. A. Anderson and Creasey's (1958) "Chaparral fault." The Chaparral fault was thought to be a profound fault separating major rock packages, but new mapping shows it to be a zone of high strain that mylonitized intruding plutons and caused only minor ( 1 km) offset of stratigraphic units as they continue across the zone (fig. 3).

**Gabbroic Bodies**

The oldest plutonic rocks in the Senator Formation are pyroxenitic enclaves in the Wilhoit batholith and pyroxene gabbro and microgabbro bodies that are subvolcanic to mafic flows of the Senator Formation. Large gabbro-microgabbro bodies occur on Spruce Mountain and to the south as the **Dandrea Ranch Gabbro,** which is newly named for its type section near Dandrea Ranch, north of Goodwin (fig. 3). The Dandrea Ranch gabbro may have subvolcanic or intrusive relations with the Senator Formation near Goodwin. Other stage 2 plutons of diorite-gabbro composition in the northern Bradshaw Mountains postdate the gabbroic bodies.

## BRADSHAW MOUNTAINS GROUP—STAGE 2

The Senator Formation is unconformably overlain to the southeast by a diverse tuffaceous sequence consisting mainly of mafic-felsic tuff, volcanic graywacke, and tuffaceous siltstone. The unconformity is of low (2- to 10-degree) angular discordance, but over kilometers of strike, substantial stratigraphic onlap occurs (fig. 3). Stratigraphy in the tuffaceous sequence is very complex, with abundant turbidites, recycling, and local unconformities; also, major facies changes exist along strike, so the sequence may be time transgressive.

**New Stratigraphy**

The tuffaceous sequence is newly and formally named the **Mount Tritle Formation** for key exposures on the east flank of Mount Tritle west of Mount Union (fig. 3). Tuffs and volcanic siltstone that unconformably overlie Senator Formation mafic volcanics near Goodwin are a facies variant of the type (Mount Tritle) locality, and may later warrant distinction as a separate but coeval formation. Both exposures of Mount Tritle Formation are unconformably overlain along their eastern side by dacitic breccias and tuffs of the Spud Mountain Formation (see Mayer Group).

**Abandonment of Former Stratigraphy**

Both the Senator and Mount Tritle Formations were collectively mapped in the past as "Green Gulch volcanics" (C. A. Anderson and Blacet, 1972a,b,c; Krieger, 1965; C. A. Anderson and others, 1971). The "Green Gulch" name has since been abandoned because it includes strata of the Spud Mountain, Senator, and Mount Tritle Formations, all of which extend across both sides of the Chaparral zone, and none of which are limited by faults (fig. 3; see P. Anderson, 1986 for details). Instead of occurring at faults, the fundamental lithologic-petrologic-geochemical breaks in the volcanic belts are stratigraphic; one such break is between strata of the Bradshaw Mountains and Mayer Groups.

**Gabbro-Diorite Bodies**

Large gabbro-diorite bodies similar to those intruding the Grapevine Gulch Formation in the Jerome volcanic belt intrude both the Senator and Mount Tritle Formations, but not the younger Spud Mountain Formation. Such bodies in the northern Bradshaw Mountains are newly named the **Lynx Creek Gabbro-Diorite** and correlate to gabbro-diorite bodies in the Grapevine Gulch Formation of the Jerome belt. Whereas the earlier microgabbro bodies are texturally gradational into basalt and conformable with Senator mafic volcanics, Lynx Creek bodies are discordant plugs and small stocks diapiric into the host volcanics.

## MAYER GROUP—STAGE 2

East of the Bradshaw Mountains near Humboldt is a tuffaceous sequence equivalent in age and stratigraphic position to the Mount Tritle Formation, but without an underlying basalt flow sequence comparable to the Senator Formation. Basal andesite flows and tuffs are overlain by tuffaceous siltstone, rhyolitic to intermediate tuff, and iron formation, among which many facies changes occur. A rhyolite dome with mineralized rhyolitic tuff facies at the stratigraphic top of the sequence is capped by a major

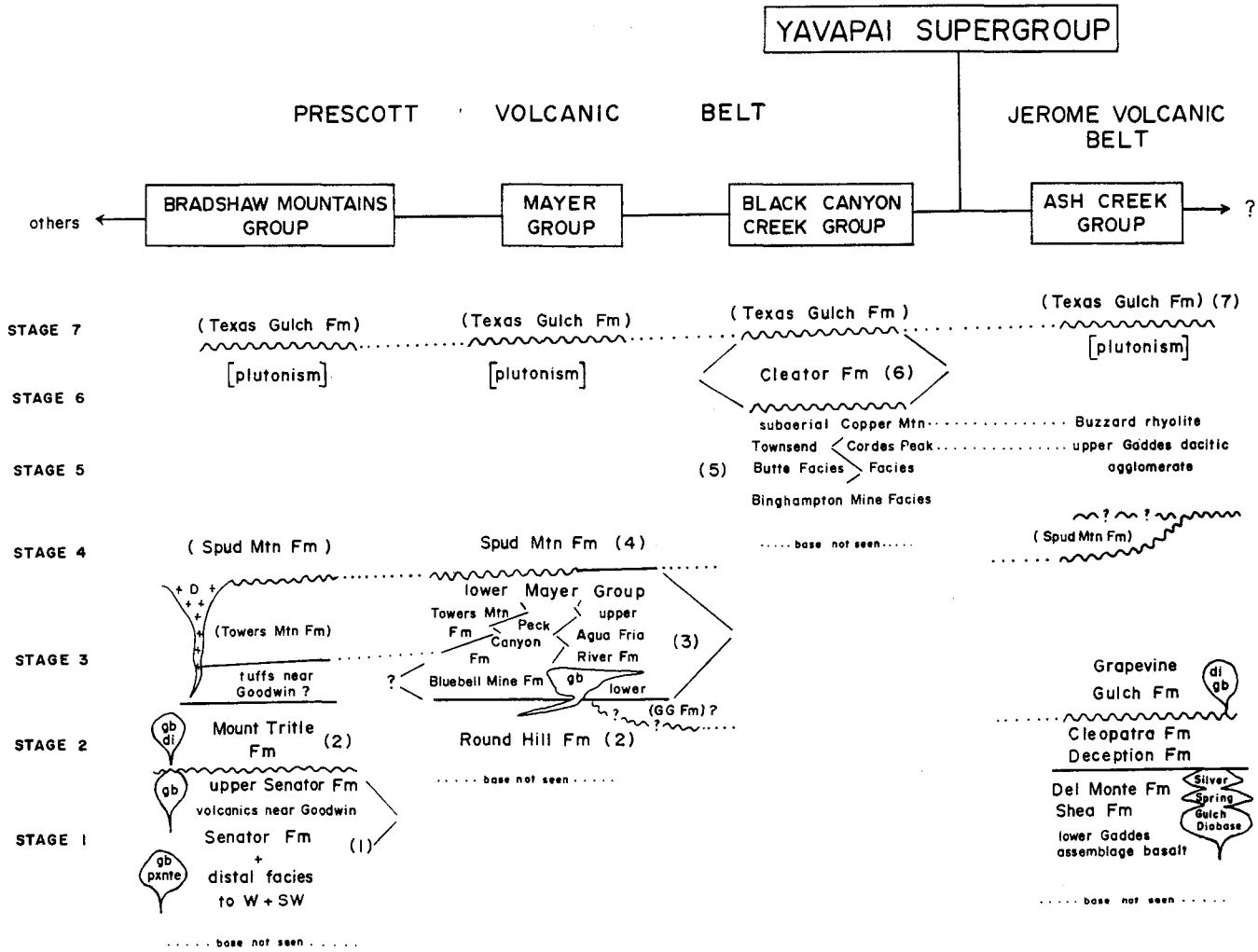



Figure 4. New stratigraphic subdivision of the Prescott-Jerome volcanic belts showing the relationship of groups and formations to depositional stages (numbers in brackets), unconformities (wavy lines), conformable contacts (straight lines), major facies changes (wedge-shaped edges), and correlations between areas (dotted lines). Departure of some unconformities from horizontal depicts the time-transgressive nature of the contacts. Formation names enclosed by brackets indicate places where the formations are not part of the major rock group beneath which they are listed (e.g., Texas Gulch Formation in the Prescott belt), but are shown in those positions only to demonstrate unconformable relations. The wedge-shaped edges of some of the major rock packages (e.g., lower Mayer Group, Cleator Formation) depict the laterally discontinuous nature of the rock units. All depositional relations have been observed in the field (P. Anderson, 1986). An early event of plutonism occurred between depositional stages 6 and 7 and is shown on the diagram only to depict unconformable relations with the Texas Gulch Formation. Abbreviations: D = dacite; di-gb = diorite-gabbro; GG Fm = Grapevine Gulch Formation; gb = gabbro; pxnte = pyroxenite.

regional horizon of iron formation (fig. 3). The tuffaceous sequence is unconformably overlain to the east by younger sedimentary rocks and conformably overlain to the west by mafic volcanics of the Mayer Group, and hence is bounded on both sides by younger rock units.

## New Stratigraphy

This tuffaceous sequence of andesitic and rhyolitic tuffs, flows, and iron formation is newly formally named the **Round Hill Formation** for exposures west of Round Hill, east of Humboldt. It correlates in time and stratigraphic position to the Mount Tritle Formation, but is slightly different. Its base is not seen, although mafic flows are more abundant in the lower parts. The Round Hill Formation is unconformably overlain to the east in the Shylock zone by the southern end of the Grapevine Gulch Formation, and is overlain to the west by pillow basalts exposed along the Agua Fria River east of Humboldt (figs. 3 and 4). Former mapping did not recognize the distinct stratigraphic position of the Round Hill Formation, and the formation, along with other rocks in the Shylock zone unrelated to true Spud Mountain pyroclastic volcanism, was included by C. A. Anderson and Blacet (1972a) in their broad "Spud Mountain volcanics" unit.

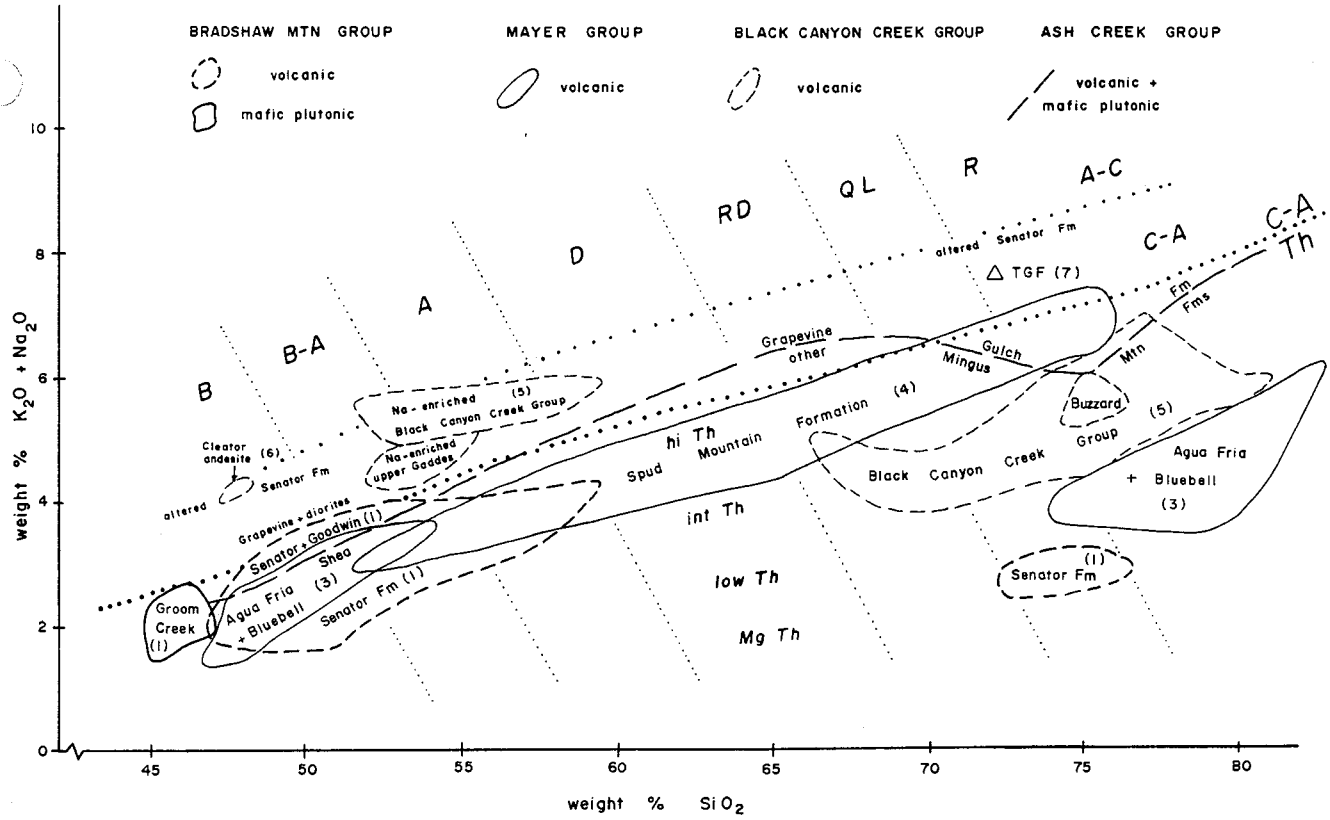



Figure 5. Alkali-silica ($K_2O + Na_2O$ vs. $SiO_2$) plot of volcanic rock groups and formations in the Prescott-Jerome volcanic belts. Lines enclose fields of analyses of unaltered, related rocks; analyses of altered rocks are not enclosed or are labeled as enriched. Numbers in brackets refer to the depositional stages discussed in text. Total number of analyses = 120. The long-dashed line at low silica values separates the Shea Formation below from gabbro-diorites in the Grapevine Gulch Formation above. TGF = Texas Gulch Formation rhyolite; Buzz = Buzzard rhyolite, Mingus Mountain. Dotted lines denote rock classification used by P. Anderson (1986) for the Arizona Proterozoic, which is similar to most conventional schemes in common use: B = basalt, B-A = basaltic andesite, A = andesite, D = dacite, RD = rhyodacite, QL = quartz latite, R = rhyolite. A-C = alkali-calcic, C-A = calc-alkaline, Th = tholeiitic (subdivided into: hi Th = high-alkali, int Th = intermediate-alkali, low Th = low-alkali, and Mg Th = magnesian tholeiitic).

across the belt with time, as shown in figure 7 by A, B, and C. Each letter corresponds to a major volcanic cycle in the Prescott belt's evolution. Under the new formal stratigraphic nomenclature established here, the *deposits of cycle A are the Bradshaw Mountains Group, deposits of cycle B are the Mayer Group,* and *deposits of cycle C are the Black Canyon Creek Group.*

With the major axis of volcanism at A (fig. 7), evolution of the belt began with a unique suite of mafic, magnesian, very low-K tholeiitic, aphyric basalt flows, bimodal basalt-rhyodacite, and subvolcanic masses, all derived directly or fractionally from olivine tholeiite parents. Closely following was extrusion of more aphyric bimodal basalt-rhyodacite flows and intrusion of olivine gabbro and pyroxenite masses, all of which were derived from an olivine tholeiite parent magma of slightly more K-Na-rich tholeiitic chemistry. Both mafic extrusive events comprise the Senator Formation and correlatives.

As the major axis of volcanism proceeded to shift from A to B, the mafic volcanic center at A was locally eroded on the east, causing andesitic graywackes and tuffs, felsic tuffs, and sediments to be shed into a wide, deep submarine basin to the east. The mafic and felsic tuffs originated from small andesite and rhyodacite-rhyolite centers within the basin. This depositional stage 2 is represented by the Mount Tritle Formation in the Bradshaw Mountains Group, and by the Round Hill Formation at the base of the Mayer Group; both are broadly coeval, but are somewhat different lithofacies.

Following mafic volcanism at axis A, mafic plutonism from quartz-normative hydrous magmas of high-K tholeiitic to low-K calc-alkaline chemistry ensued at A. Both the Senator and Mount Tritle Formations were intruded by diapiric gabbro-diorites of different chemistry than the earlier gabbro-pyroxenites coeval with the volcanics. Emplacement of these gabbro-diorite bodies may have been synchronous with inception of stage 3 volcanism at a new axis to the east.

Next, the major axis of volcanism shifted far enough east of the stage 1 edifices for an entirely separate volcanic center to evolve at B during depositional stage 3 (fig. 7). Phenocrystic pillow basalt flows, tuffs, and agglomerates were extruded from gabbro centers into a deep-water submarine setting during stage 3 and were interbedded with

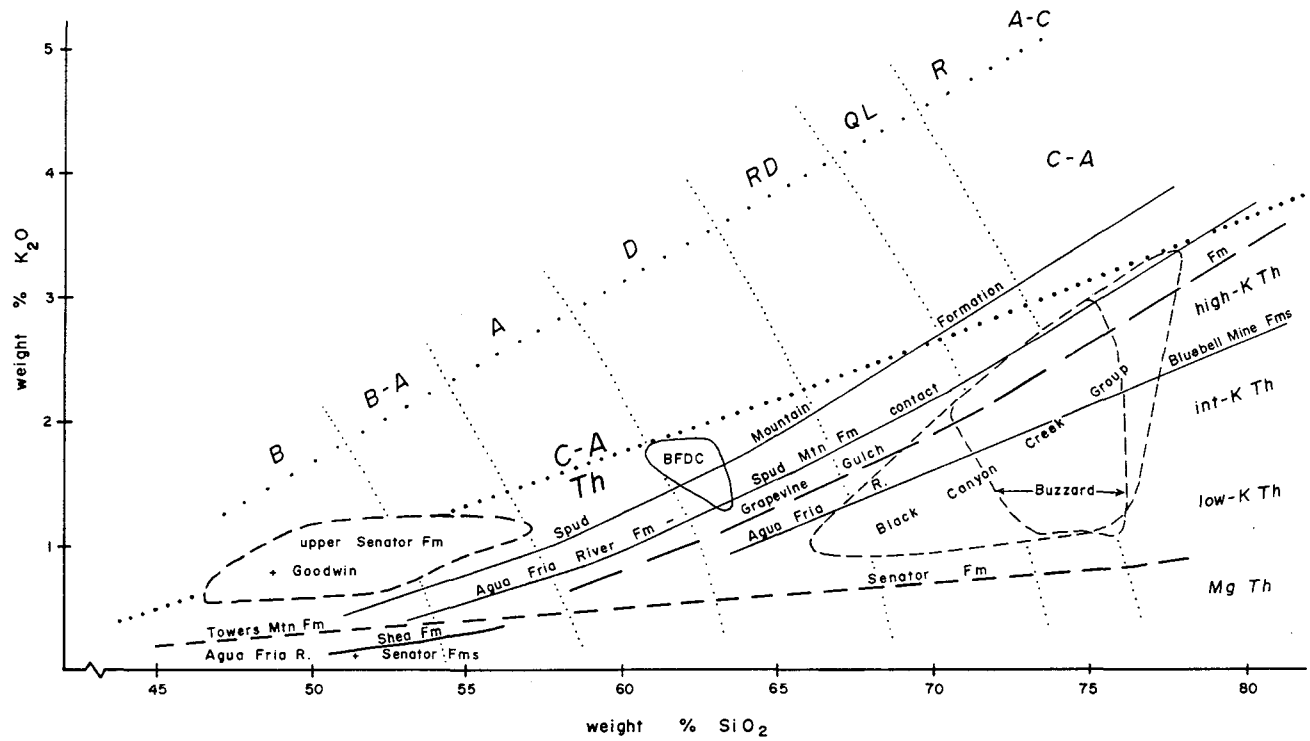



Figure 6. $K_2O$ vs. $SiO_2$ plot showing K-enrichment trends of volcanic rock groups and formations in the Prescott and Jerome volcanic belts. Each line represents an average trend of related mafic and felsic volcanic rocks. BFDC = Battle Flat dacite center analyses. Rock classification scheme is the same described in figure 5 except that the tholeiitic field is subdivided into high-K tholeiitic, intermediate-K tholeiitic, and low-K tholeiitic; these terms are used in a relative sense and not meant to imply $K_2O$ contents as high as calc-alkaline.

rhyolite flows, tuff, and iron formation. The earliest part of the mafic accumulation was the Bluebell Mine Formation, then the Peck Canyon and Towers Mountain Formations in the south, then the Agua Fria River Formation in the north. The lowest units are low-alkali tholeiitic, normal Fe-rich bimodal basalt-rhyolite derived by differentiation of quartz-tholeiite parent magmas. The tholeiitic parent underwent fractionation by removal of early pyroxene phases to produce a higher-K tholeiitic basaltic andesite source magma dominated by plagioclase. This new source underwent further fractional crystallization to produce high-K tholeiitic andesites and rhyolites in the upper Agua Fria River Formation.

At this point an important trend in the lithologic makeup of the entire volcanic belt was established. The preceding large jump in the major axis of volcanism from position A, where the Bradshaw Mountains Group developed, to site B, where the Mayer Group evolved, left a gap or deep trough in the supracrustal deposits which was only partly filled by distal strata interleaved at the edges of both major volcanic edifices. Thus, volcanism from the second major cycle at site B proceeded to backfill the trough in a transgressive manner that caused only the youngest deposits of the Mayer Group—the Spud Mountain Formation—to lap unconformably back over older sequences to the west, including Mount Tritle and Senator Formations plus their gabbro-diorites.

Plagioclase-crystal dacite-andesite breccias in lowest parts of the Spud Mountain Formation are petrochemically related to waning Agua Fria River volcanism, whereas middle and upper parts were derived from an evolved tholeiitic to calc-alkaline differentiated magma extruded from the Battle Flat dacite center. Most pyroclastics were shed northward from the Battle Flat center to fill the intervolcanic trough and lap over older rocks to the east and west, leaving the Spud Mountain Formation as a laterally discontinuous rock package with older mafic volcanics on either side.

The major volcanic axis took another large jump from positions B to C after Mayer Group volcanism ceased, and the same pattern of establishing a new volcanic center far to the east and subsequently backfilling the intervening intervolcanic trough to the west was repeated at axis C. The first new extrusives of the Black Canyon Creek Group were dacite-rhyodacite flows, tuffs, and breccia of phenocrystic character similar to Spud Mountain rocks, but with different chemistry. The first phenocrystic agglomerate and conglomerate heralded an impending major outpouring of vast quantities of aphyric felsic agglomerates and breccias across the eastern Prescott and Jerome belts, which had been stratigraphically linked long before Spud Mountain time.

As the Copper Mountain center evolved into a large subaerial felsic complex east of Mayer, the Prescott-Jerome

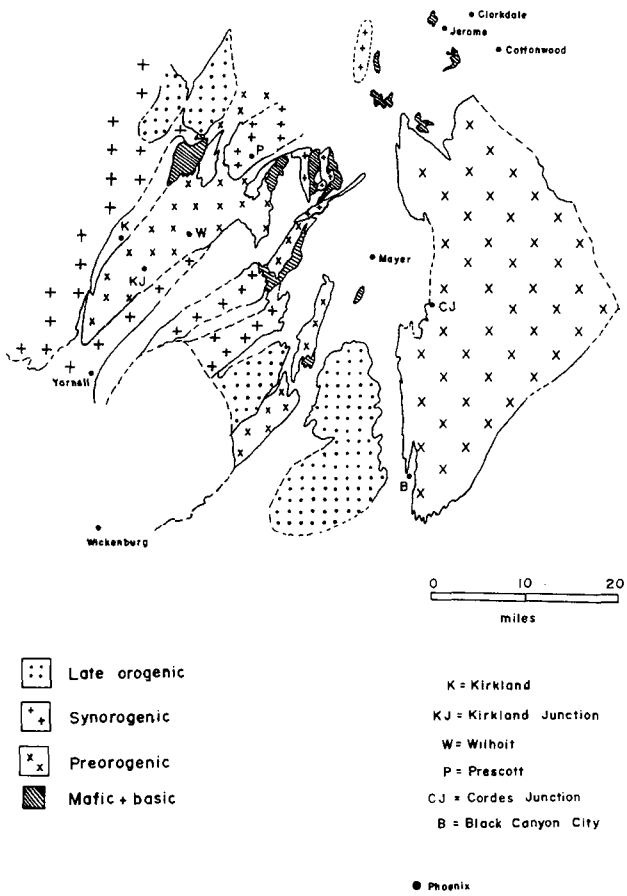



Figure 13. Location map of older plutonic rock suites in the Prescott region.

metamorphic terranes with migmatite-anatectic complexes, because they were emplaced during the thermal culmination of orogenic activity. They usually strongly deformed their host strata, but are not strongly deformed themselves, except at their contacts. Truly posttectonic plutons are undeformed and cut earlier deformed fabrics. Many key petrologic features support such distinctions: for example, late-tectonic plutons are typically K-feldspar phenocrystic whereas pretectonic and early syntectonic plutons are not.

## GEOLOGY AND GEOCHEMISTRY OF PLUTONIC SUITES

Figure 13 shows the general distribution of orogenic plutonic bodies in the Prescott region. Figure 14, a more detailed map of the Bradshaw Mountain-Prescott area compiled from new 7.5′ quadrangle mapping (P. Anderson, 1986), shows the locations of all batholiths and plutons discussed here. The order in which the bodies are described here is similar to that in tables 1 and 2, p. 115 and 116. Table 1 subdivides plutonic rocks in the Prescott region solely by relative-age relationships observed in the field. This is the primary basis for a more detailed subdivision into plutonic suites that are genetically related by major petrologic and geochemical attributes (table 2). Figures 15, 16 and 17 summarize key major- and trace-element chemical data for the plutonic bodies discussed in this paper.

An increase in alkali content with time, particularly $K_2O$, of plutonic bodies in the Prescott region is manifested as two separate trends, both of which were caused by a single tectonic process: (1) in any one area, the $K_2O$ and total alkali contents of plutonic rocks emplaced generally increase with time; and (2) the $K_2O$ and total alkali contents of plutonic rocks as a whole increase to the northwest across the region, in parallel with a northwest-younging of emplacement ages (P. Anderson, 1976, 1978a). The tectonic significance of the northwest alkali enrichment trend, opposite to the southeast alkali enrichment in host volcanic rocks of the Prescott volcanic belt, is discussed elsewhere [see tectonics paper].

The key field relationships and most important lithologic, petrologic, and geochemical features of all major plutons and batholiths in the Prescott region are summarized below, from generally oldest to youngest. The oldest bodies are typically not the most strongly deformed, because many lie in regions of low strain, but they are intruded and diked by younger syn- and late-tectonic ones, thus offering clear evidence as to their relative emplacement ages. In the following discussion, these relative ages are referenced, using pre-, syn-, and posttectonic terms, to the main 1700-Ma event of deformation (tables 1 and 2). A numerical emplacement chronology, referenced to the few isotopically dated bodies, is given at the end of this paper.

### GROUP 1: EARLY SYNVOLCANIC AND INTERVOLCANIC MAFIC PLUTONS

**Earliest Synvolcanic Gabbro Plutons**

The earliest mafic volcanic extrusions of the Prescott-Jerome belts were fed by hypabyssal magmas that crystallized as fine-grained gabbros. One major hypabyssal feeder to early mafic volcanic rocks of the Jerome volcanic belt was the Silver Spring Gulch Diabase, which consists of an upper fine-grained diabase and intrusive basaltic andesite, and a lower differentiated diabase, microgabbro, diorite, granodiorite, and monzogranite. Geochemically the diabase is a low-$K_2O$, calcic, tholeiitic diabase on a true iron-rich differentiation trend, like that of the host bimodal tholeiites of the Shea and Del Monte Formations (figs. 14, 15, and 16).

In the Prescott volcanic belt, the oldest plutons are mafic Mg-rich subvolcanic gabbro feeders. Both the Dandrea Ranch gabbro and the gabbro of Spruce Mountain in the northern Bradshaw Mountains (figs. 3 and 14) are calcic-series microgabbros that intrude bimodal Mg-tholeiitic basalt and sodic rhyodacites of the Senator Formation, but that predate mafic volcanic units of the upper Senator and Mount Tritle Formations. Gabbros in the Bluebell Mine and Towers Mountain Formations south of Mayer are coeval with tholeiites of the lower Mayer Group. These gabbros are slightly more alkali rich than those in the

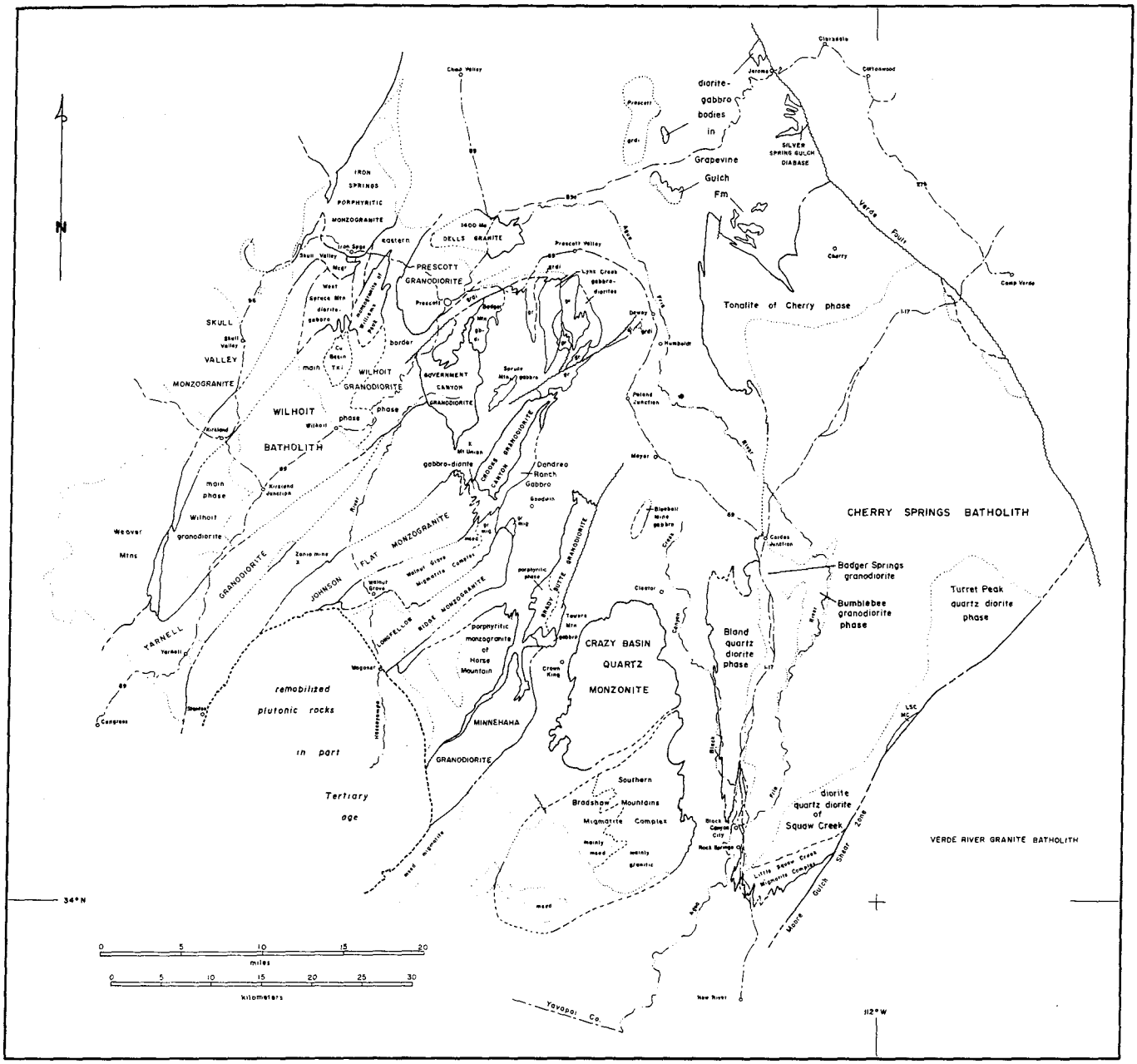



Figure 14. Geologic map of the Bradshaw Mountains-Prescott region showing the major plutonic bodies. The generalized outcrop limits of the plutonic rocks are shown by thin dotted lines where covered by post-Proterozoic rocks, and by short dashed lines where cut by post-Proterozoic intrusive rocks. The contacts of the plutonic bodies with Proterozoic metavolcanic and metasedimentary rocks are shown by solid and dashed lines, but are dotted where projected under cover. Figure 3 is the inverse of this figure, in that the blank areas on this figure are differentiated into the main Proterozoic volcanic and sedimentary rock units of the Prescott region, whereas the blank areas on figure 3 are differentiated here as the main plutonic bodies of the Prescott region.

Senator Formation and are part of the same iron-rich tholeiitic differentiation trend that characterizes the host trimodal basalt-dacite-rhyolite suite of the lower Mayer Group (figs. 5, 6, 15, 16).

Mafic gabbros near Prescott and at Cordes near Mayer are even more Mg rich than Bluebell-type calcic gabbros, with a magnesian-series magma chemistry (figs. 15, 16) and olivine from their olivine-tholeiite parents. Similar Mg-rich gabbros occur with gabbro-diorites in the Grapevine Gulch Formation of the Indian Hills northeast of Prescott. The Mg-rich gabbros appear to be coeval with the earliest calcic gabbros, and together show that the earliest plutons of the Prescott-Jerome volcanic belts were derived from very mafic, magnesian, low-alkali, calcic-series magmas. This earliest gabbro suite is petrochemically important to understanding the evolution of central Arizona's earliest

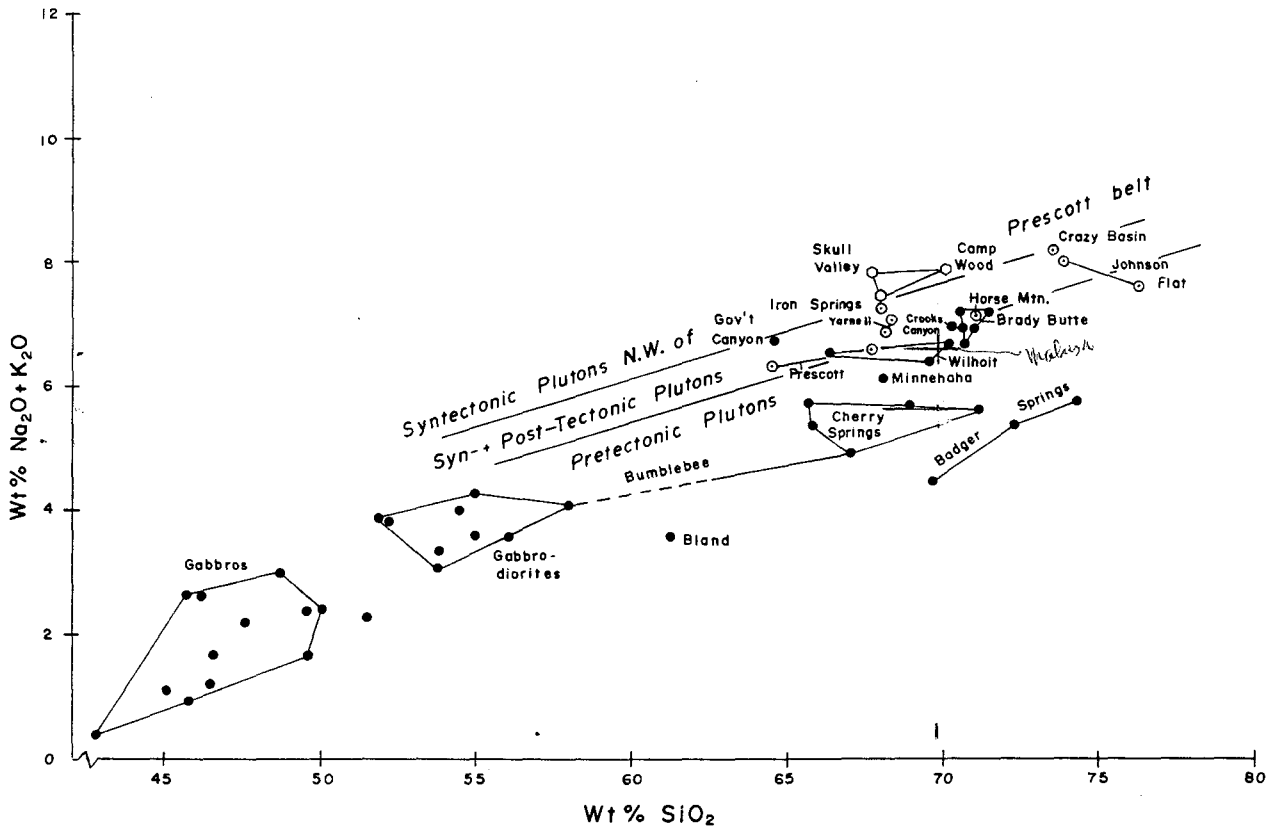



Figure 15. Alkali-silica diagram for plutonic rocks in the Prescott region. Only representative analyses from each plutonic body are shown, and the general fields of pre-, syn-, and posttectonic plutons are derived from a plot of all plutonic chemical data from central and northwest Arizona, totaling over 200 analyses. Analyses labeled as "Johnson Flat" are from related dikes, which may not be the same composition as the main Johnson Flat body. The terms "calcic, calc-alkaline, alkali-calcic" and "low-K, intermediate-K and high-K" both here and on the alkali-silica diagrams are relative, not absolute, and are taken from the classification scheme of P. Anderson (1986), which is similar to Keith's (1978) and most others in common use.

contained within the west-central part of the Prescott volcanic belt. The Minnehaha Granodiorite southwest of Crown King is nongneissic, and is more mafic than and very different from the Brady Butte Granodiorite.

The Brady Butte is a leucocratic granodiorite with resorbed hornblende and minor biotite, magnetite, chlorite and muscovite from subsolidus biotite reaction. Chemically, the pluton is calc-alkaline and is higher in Si, K, and Na, and lower in Fe, Mg, Ti, and Ca than other plutons of comparable age (e.g., Government Canyon Granodiorite). The southern porphyritic quartz monzonite (monzogranite) phase near Tuscumbia Mountain (C. A. Anderson and Blacet, 1972a,b,c) has abundant trachytic K-feldspar phenocrysts, is almost chemically identical to the main granodiorite phase, and has the same distinctive gneissosity.

***Crooks Canyon Granodiorite (C. A. Anderson and Blacet, 1972a,b,c).*** The map unit originally shown by C. A. Anderson and Blacet (1972b) as Crooks Canyon Granodiorite is not a single pluton like the Brady Butte, but a migmatite complex in which swarms of younger fine-grained granitic dikes invade a coarse-grained, gneissic granodiorite and its host metavolcanic-metasedimentary strata. The older gneissic granodiorite is the most important part of this complex and is the rock C. A. Anderson and Blacet (1972b) originally intended to bear that name, so the term "Crooks Canyon Granodiorite" is redefined as only the older coarse-grained gneissic granodiorite of the complex, not any other rocks (P. Anderson, 1986). C. A. Anderson and Blacet's (1972b) original "Crooks Canyon" map unit is true Crooks Canyon gneissic biotite granodiorite only in some places; elsewhere their map units includes migmatite and paragneiss, younger fine-grained red granite locally deformed to ribbon mylonite in the Chaparral high-strain zone, and fine-grained granite and monzogranite dikes. These younger granitic rocks stem from younger plutons to the south—the Johnson Flat and Longfellow Ridge bodies—which belong to a later plutonic suite that caused high-grade metamorphism and migmatization in the complex.

True Crooks Canyon Granodiorite is a leucocratic biotite granodiorite with a low mafic content and a pervasive gneissic fabric. Thus, it is much like the Brady Butte body, but shows no porphyritic character, muscovite, or hornblende reactions. The major-element chemistries of

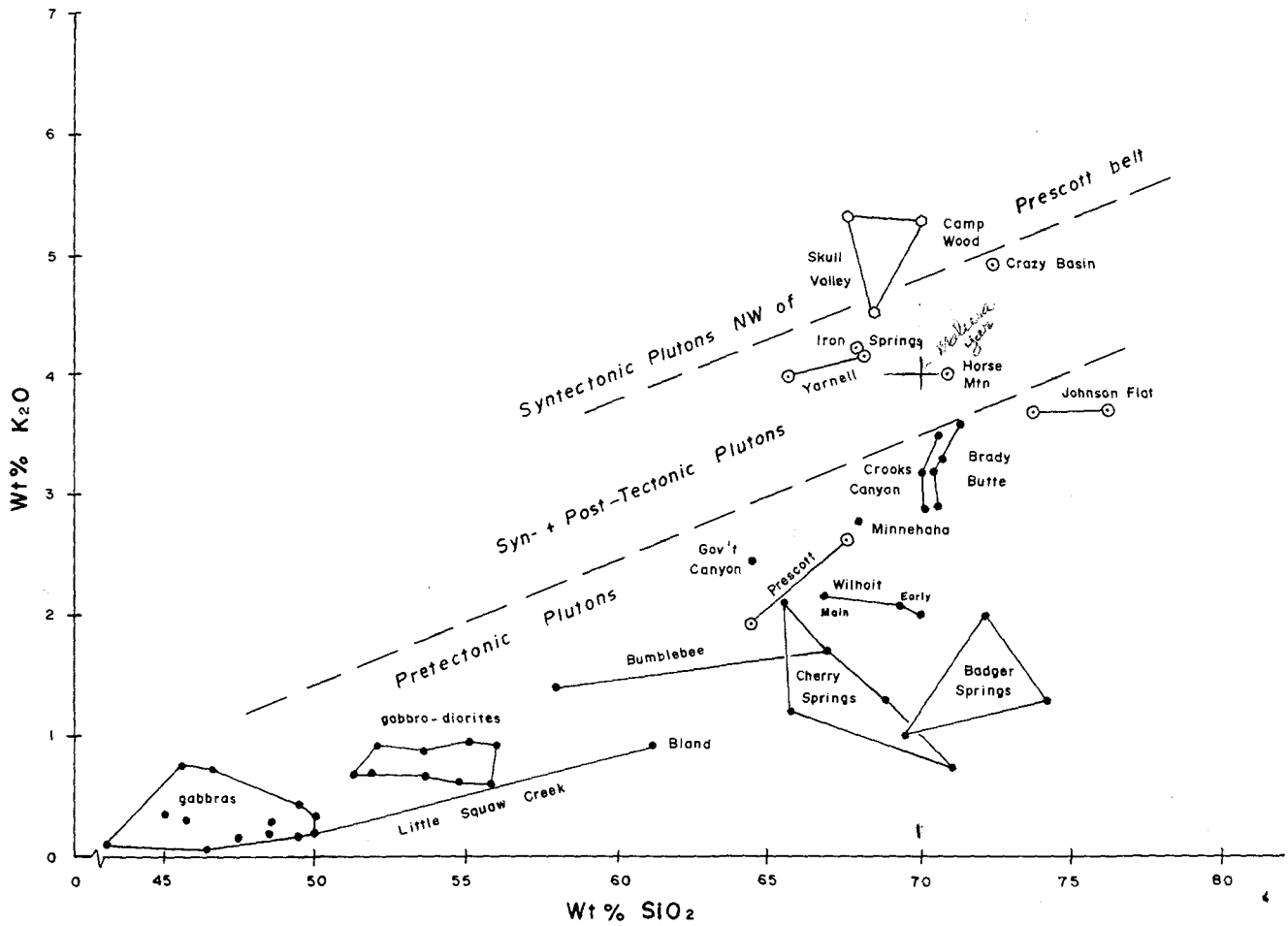



Figure 16. $K_2O$ vs. $SiO_2$ diagram for plutonic rocks in the Prescott-Jerome region. Only representative analyses from each plutonic body are shown, and the general fields of pre-, syn-, and posttectonic plutons are derived from a plot of all the plutonic data from central and northwest Arizona, totaling over 200 analyses. Analyses labeled as "Johnson Flat" are from related dikes, which may not be the same composition as the main Johnson Flat body.

north where the migmatite zone grades into coherent plutonic rock. Farther north, coarse-grained, foliated hornblende-biotite tonalite grades into granodiorite towards Turret Peak. All of these plutonic phases are metaluminous and of calcic chemistry, with compositions spanning all previous fields, including gabbros at the west edge of the batholith.

The less foliated, hornblende-biotite granodiorite and quartz diorite exposed between Turret Peak and Brooklyn Peak is intruded to the west by Badger Springs Granodiorite in a zoned relationship similar to that of Badger Springs Granodiorite intruding Bumblebee Granodiorite to the west. The quartz diorite-granodiorite phase of Turret Peak and all southerly diorite, quartz diorite, and granodiorite phases of Little Squaw Creek likely predate Bland quartz diorite, and may be 1740 Ma, especially since Alder strata to the south are not metamorphosed by them.

## GROUP 3: MIDDLE (SYNTECTONIC, LATE-TECTONIC) GRANODIORITE-MONZOGRANITE PLUTONS

Group 3 plutons belong to a later stage in the evolution of central Arizona, after the major batholiths and plutons of group 2 had largely stabilized and thickened the volcanic belts. They are distinctively more leucocratic, finer grained, and more evolved in petrology and chemistry than preceding plutons and batholiths, and in all cases intrude the pretectonic group 2 granodiorite plutons and batholiths.

Prescott Granodiorite, the monzogranite of Williams Peak, and Skull Valley Monzogranite all intrude the Wilhoit batholith, sending swarms of fine-grained dikes into the batholith. The Johnson Flat and Longfellow Ridge Monzogranites intrude Crooks Canyon Granodiorite and its host strata, and likewise pervade them with swarms of fine-grained dikes. Such relationships suggest a common

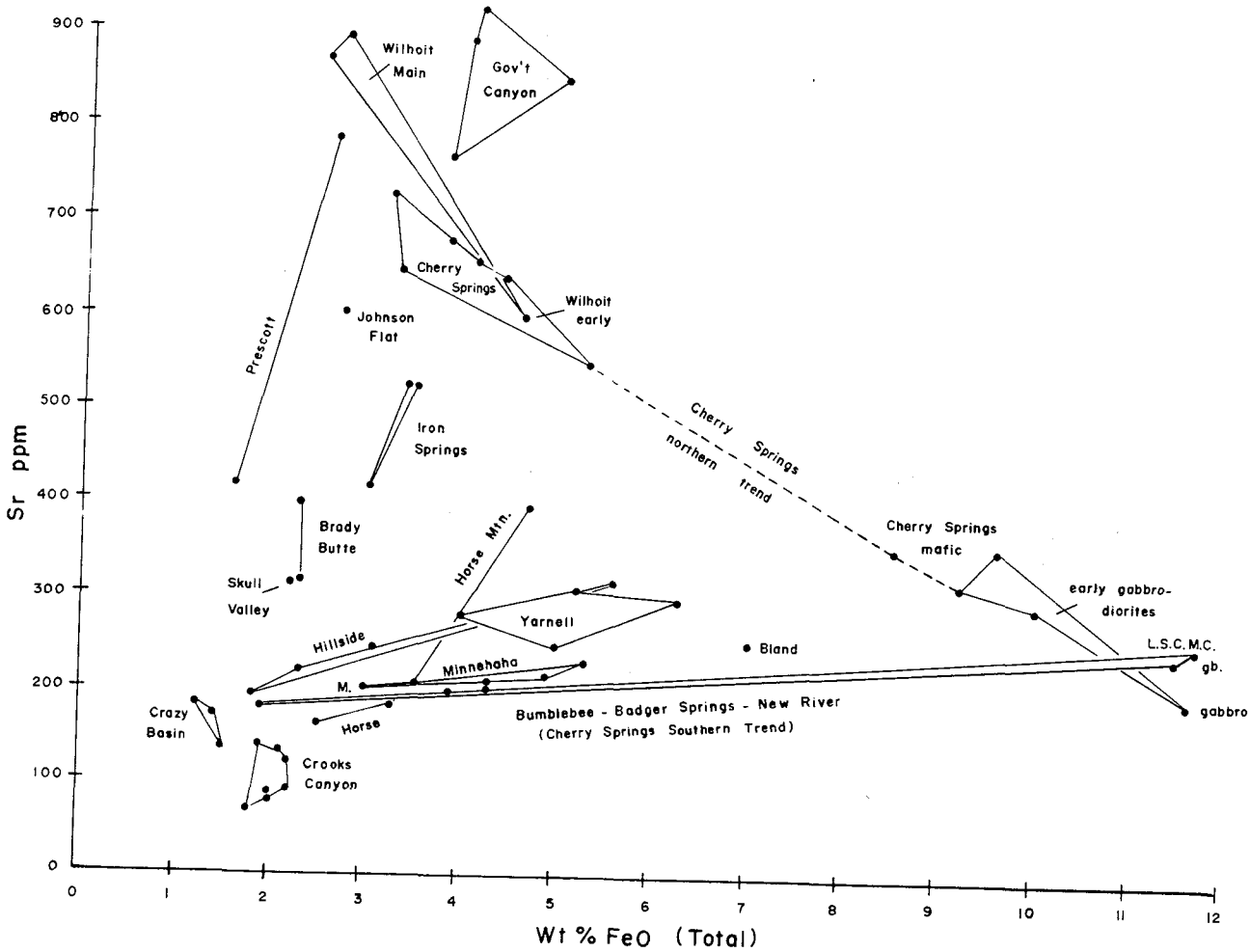



Figure 17. Sr vs. total Fe expressed as FeO for plutonic rocks in the Prescott-Jerome region. L.S.C.M.C = Little Squaw Creek Migmatite Complex. All Sr analyses were performed by the U.S. Geological Survey and the data has been generously supplied by Ed DeWitt.

the Johnson Flat Monzogranite, but is more strongly foliated, altered, and iron stained at its borders. Swarms of fine-grained red granitic dikes from the body intrude the Crooks Canyon Granodiorite and Dandrea Ranch gabbro, forming another migmatite analogous to the Walnut Grove Migmatite Complex (fig. 14).

The Longfellow Ridge and Johnson Flat bodies are chemically similar, but a southward progression through group 3 plutons encounters progressively more felsic compositions, such that each successive body is less Ca-Sr rich and more Si-Al-K rich than its northern neighbor. This gradual chemical change closely parallels the change in chemistry of host volcanic units across the southwest flank of the Bradshaw Mountains. Thus, the Longfellow Ridge is a weakly peraluminous, high-K calc-alkaline monzogranite with lower Ca, Mg, Fe, and Sr than Prescott Granodiorite, and it intrudes a host crust equally depleted in these elements, compared to the more primitive host crust of the Prescott body to the north.

***Skull Valley Monzogranite (new formal name; P. nderson, 1986).*** The Skull Valley Monzogranite is an eastern border phase of a huge batholith that extends west through Hillside towards Bagdad. The entire batholith appears homogeneous and seems to consist of coarse-grained, massive, bouldery weathering monzogranite with small K-feldspar phenocrysts. The batholith differs from nonporphyritic group 3 plutons in its weakly porphyritic texture, but the Skull Valley Monzogranite is included in group 3 because of similarities in texture, composition, and age relations to other group 3 plutons. The Skull Valley Monzogranite is weakly foliated and intrudes the pretectonic Wilhoit batholith; however, it is cut by the Iron Springs Porphyritic Monzogranite (fig. 14), so is close in age to the Williams Peak body, which is likewise deformed where intruded by unfoliated Iron Springs Porphyritic Monzogranite. Moreover, swarms of nonporphyritic monzogranite dikes that extend northeast from the Skull Valley body are indistinguishable from dikes of the Williams Peak and Prescott bodies.

Skull Valley Monzogranite is separated from the Wilhoit batholith by a persistent metavolcanic screen that extends from Kirkland north to West Spruce Mountain (fig. 14), and

only farther north does it intrude the Wilhoit Granodiorite. In the type area at Skull Valley, the rock is a medium- to coarse-grained, weakly porphyritic, K-feldspar-rich monzogranite with abundant biotite and minor muscovite. Phenocryst size increases to the west, but decreases easterly towards its contact.

Chemically, the Skull Valley body is higher in K and Ti, and lower in Ca, Al, Na, Mg, and Fe than Prescott Granodiorite. Skull Valley Monzogranite is similar to, but has higher K/Na than, the monzogranite of Horse Mountain: both bodies plot in similar positions on figure 17 and are notably lower in Sr than all other group 3 plutons, as are their sedimentary host rocks. However, the Skull Valley Monzogranite and its related batholith to the west are clearly peraluminous, and were emplaced into a much more felsic, nonvolcanic host crust than were plutons to the east. This sedimentary crust appears to be unrelated to the Prescott-Jerome belts [see Part 1], and the difference in crustal composition is clearly reflected in the more peraluminous, evolved nature of plutonic rocks to the west.

## GROUP 4: LATE (LATE-TECTONIC) PORPHYRITIC MONZOGRANITE-GRANITE PLUTONS AND BATHOLITHS

### Coarsely Porphyritic

The late-tectonic group 4 plutons are distinctive in their coarsely porphyritic habit and weakly foliated to unfoliated character. They typically intrude other plutons that were deformed either before or during their emplacement. It cannot be shown from relative-age relations alone whether all members of this group were emplaced concurrently, mainly because no pluton comes in contact with another. Strict temporal concurrence is unlikely, however, because of age differences in their associated metamorphic events, as noted later. In particular, migmatization related to the Crazy Basin Quartz Monzonite postdated emplacement of the Horse Mountain body and probably that of all other porphyritic plutons as well.

***Yarnell Granodiorite (new formal name; P. Anderson, 1986).*** The Yarnell Granodiorite is named for exposures of foliated, coarse-grained porphyritic granodiorite to monzogranite just north of Yarnell. More coarsely porphyritic monzogranite comprises a vast batholith in the Weaver and the Date Creek Mountains to the southwest (fig. 14), but this batholith is largely unstudied and may involve 1400-Ma plutonic rocks. The Yarnell Granodiorite is therefore discussed separately from the batholith, even though their chemistries are similar (fig. 17). The Yarnell Granodiorite follows the northwest edge of the Stanton-Octave metavolcanic-metasedimentary screen to as far north as Wilhoit (fig. 14), where dikes of unfoliated Yarnell Granodiorite intrude foliated granodiorite of the Wilhoit batholith.

The Yarnell Granodiorite is distinctively coarse grained and weakly foliated, with large pinkish-tan K-feldspar phenocrysts in an equigranular matrix with biotite, plagioclase, uncommon hornblende, and abundant sphene. Macroscopically it resembles no other rock in the Prescott region; it is similar to 1400-Ma granite in phenocryst habit, but the main Yarnell body is deformed and not a 1400-Ma body. The main K-feldspar is twinned microcline, a mineral not found in most preceding plutonic rocks. Where the rock is foliated, oligoclase, perthitic microcline, quartz, and biotite are recrystallized to fine aggregates of sericite, quartz, feldspar, biotite, chlorite, and magnetite. Yarnell Granodiorite is diagnostically rich in sphene.

Chemically the Yarnell body is a metaluminous, high-K calc-alkaline, high-Fe-Ti and high-total-alkali rock of monzogranite to granodiorite composition. It appears to have been derived by fractional crystallization that started in the plagioclase-hornblende field, but it largely crystallized before reaching the eutectic, because microcline and quartz are interstitial to orthoclase and plagioclase. In biotite granodiorite compositions, hornblende survives as only a partly reacted constituent, but in porphyritic monzogranite compositions it is almost totally reacted to biotite, chlorite, and magnetite.

***Porphyritic monzogranite of Horse Mountain (new informal name; P. Anderson, 1986).*** In the southern Bradshaw Mountains is the distinctive porphyritic monzogranite of Horse Mountain, which intrudes the north edge of the Minnehaha Granodiorite (fig. 14). The Horse Mountain monzogranite is distinguished by its large, tabular, trachytic K-feldspar crystals in a foliated biotite-rich matrix. Pegmatite dike swarms pervade central and contact regions of the body, extend north to cut Longfellow Ridge Monzogranite, form a narrow migmatite zone along the southeast border of the pluton, extend southwest to intrude Minnehaha Granodiorite, and extensively inject the body itself.

The porphyritic monzogranite has distinctive fresh 1-cm-long, Carlsbad-twinned K-feldspar phenocrysts in a finer matrix of quartz, plagioclase, K-feldspar, and biotite flakes, which locally show subsolidus reaction to muscovite, even though the rock is not chemically peraluminous. In fact, low Al content and high Si, K, and Na contents are the rock's main chemical features. Minor hornblende occurs in more strongly foliated rocks to the south. Andalusite-cordierite metamorphic mineral facies along the east side of Horse Mountain body are overprinted farther to the east by higher pressure mineral facies related to the younger Crazy Basin Quartz Monzonite (see below).

The monzogranite of Horse Mountain has a trace-element profile like Yarnell Granodiorite, and was derived from a magma chemically similar to that of the Yarnell or Iron Springs plutons. In addition, overlap of analyses from the Horse Mountain and Minnehaha plutons (fig. 17) is

volcanic rocks, hypabyssal microdiorite, and andesitic tuffs. Foliated dioritic rocks with septa of meta-andesite and microdiorite dominate the northern 1.5 km of the zone, strongly lineated granitic gneiss interlayered with meta-andesite and tuff make up the central 1 km, and granodioritic gneiss injecting meta-andesitic tuffs dominate the southern part of the zone. Metamorphism throughout the Little Squaw Creek Migmatite Complex is of lower amphibolite facies, but the southeast edge of the complex demarcates a steep metamorphic gradient, south of which lower greenschist grade tuffs and schistose metasedimentary rocks occur in Moore Gulch.

Farther north along the eastern Cherry Springs batholith contact near Brooklyn Peak, the same complex exists at higher amphibolite metamorphic grades but is of more limited extent, being partly cut off by the Moore Gulch shear zone. Consequently, the widest migmatite zone of the Cherry Springs batholith is associated with diorite and quartz diorite border phases on its east side, not with the main granodiorite-tonalite phase to the west.

**Minnehaha Granodiorite**

The Minnehaha Granodiorite, like the Cherry Springs batholith, has a wide contact migmatite zone along the southeast edge and narrow aureole to the northwest, except for later migmatization to the north by pegmatite dikes from the Horse Mountain pluton. The eastern side of the Minnehaha Granodiorite contains many amphibolite and biotite gneiss enclaves from a screen of metavolcanic and metasedimentary rocks that separates it from the Horse Mountain and Brady Butte plutons. Metamorphism in this screen is discussed in the section about the Horse Mountain pluton.

The wide southeastern contact of the Minnehaha pluton involves a 1-km-wide zone of granodiorite with mafic metavolcanic septa, bordered by a 2-km-wide migmatitic zone of paraschist and gneiss (cordierite-muscovite schists and muscovite-tourmaline hornfels) injected by granodiorite and pegmatite. This amphibolite-grade metamorphic aureole merges southward into pervasive amphibolite (cordierite-garnet-andalusite) metamorphic conditions as the regional thermal gradient increases southwesterly into the Morgan Butte-Red Picacho area near Wickenburg.

**Wilhoit Batholith**

The southeast edge of the Wilhoit batholith is a 2-km-wide migmatite zone near Wilhoit that includes amphibolite-grade mafic metavolcanic and metasedimentary rocks and partly assimilated gabbroic septa representing fragments of the west edge of the Prescott volcanic belt. These mafic migmatites extend to just northeast of Prescott, past which Mount Tritle Formation tuffs predominate in the migmatite zone in Prescott Valley (fig. 14). The Wilhoit Granodiorite thus skirts the entire northwest edge of the Prescott belt, incorporating whatever host rocks exist at each locality into its contact migmatite zone.

The western contact of the Wilhoit batholith appears sharper but is intruded by Skull Valley Monzogranite along much of its length. Three screens of metavolcanic-metasedimentary rock near Kirkland mark the boundary between Skull Valley Monzogranite and the Yarnell and Wilhoit Granodiorites (fig. 14). Farther north near Copper Basin, Wilhoit Granodiorite complexly intrudes, metamorphoses, and migmatizes gabbro-diorite of West Spruce Mountain and its host mafic and felsic volcanosedimentary rocks, forming a migmatite like that at the batholith's eastern contact, except for the different host rocks.

A key feature of contact-metamorphic effects around all plutons and batholiths discussed so far is the paucity of aluminosilicate index minerals or diagnostic assemblages in metapelitic rocks. Metapelites in the metamorphic aureoles of all later plutonic suites have such index minerals, and so P-T differences can be analyzed more accurately between the later syntectonic plutonic suites.

## GROUP 3 SYNTECTONIC INTERMEDIATE PLUTONS

Whereas contact zones of pretectonic plutons and batholiths involved passive assimilation in a static environment, the syntectonic plutons were intruded into a dynamically stressed environment, so their emplacement was forceful and accompanied by dike swarms and formation of stress-controlled, injection-migmatite complexes. These dike swarms parallel northeast-trending pluton contacts, are most intense at pluton margins, and extend away from the ends of plutons like fingers from a hand, to gradually die out away from their source. Thermal metamorphism of host rocks is linked to the size and extent of the dike swarms, and is regional only where dike swarms are extensive. Away from pluton margins and dike swarms, metamorphic grades drop sharply from amphibolite to greenschist facies.

The Prescott Granodiorite and the monzogranites of Williams Peak, Johnson Flat, Longfellow Ridge, and Skull Valley all produced dike swarms and zones of injection migmatization at their borders and outward from their ends. The Johnson Flat swarm migmatizes Mount Tritle volcaniclastics throughout a 15-km-long, northeast-trending zone that was also a locus for the Chaparral shear zone. Dike swarms between the Johnson Flat and Longfellow Ridge bodies produced the Walnut Grove Migmatite Complex from strata of the Spud Mountain, Senator, and Mount Tritle Formations (fig. 14). Dikes from the Skull Valley body produced a long north-trending migmatite zone truncated by the later Iron Springs pluton. Emplacement of all group 3 syntectonic plutons, dikes, and injection migmatites caused deformation that produced foliation and lineated gneissic fabrics in host strata.

## GROUP 4 LATE-TECTONIC PORPHYRITIC PLUTONS

Porphyritic plutons of late-tectonic group 4 produced various contact effects depending their host rocks. The Iron

Springs body near Prescott has sharp contacts with few dikes and a contact metamorphic aureole less than 1 km wide, involving retrograding of earlier amphibolite-grade metamorphic assemblages and K-feldspar metasomatism. The Yarnell Granodiorite produced a 100-m-wide cordierite-biotite hornfels aureole in dacite flows and breccias in the Stanton-Octave screen, and weak thermal effects up to 250 m from the contact. Yarnell Granodiorite is locally separated from Hillside and Skull Valley Monzogranites to the west by screens of amphibolite-grade metavolcanic and metasedimentary rocks (fig. 14).

A thin, persistent metamorphic screen, which separates the Horse Mountain monzogranite from Minnehaha and Brady Butte Granodiorites (fig. 14), shows a background lower greenschist grade increasing to amphibolite facies toward the Horse Mountain pluton. Amphibolite facies persist for up to 1 km east of the Horse Mountain pluton, as evidenced by metapelites with porphyroblastic cordierite-andalusite, muscovite, and biotite, and by mafic tuffs of hornblende-epidote-plagioclase mineralogy. Rotated inclusion trains in cordierite porphyroblasts and strong matrix foliation indicate that deformation outlasted recrystallization in this metamorphic screen. These amphibolite-grade assemblages define a low-pressure facies series, and their timing shows that the Horse Mountain monzogranite was emplaced in a syntectonic or late-tectonic setting where deformation outlasted cooling below the amphibolite isograd. Exactly the opposite is true in the metamorphic aureole of the Crazy Basin body less than 10 km to the east, where recrystallization clearly outlasted deformation, and metamorphic assemblages are indicative of a higher temperature, higher pressure facies.

Such contrasts indicate that the late-tectonic Crazy Basin granite clearly postdated the Horse Mountain pluton and the other porphyritic plutons by an important time interval, after which significantly higher pressure and higher temperature metamorphic facies developed within a broad region of crustal anatexis in the southern Bradshaw Mountains.

## GROUP 4 LATE-TECTONIC PLUTONS AND ANATECTIC COMPLEXES

Latest group 4 felsic plutons and batholiths are characterized by widespread migmatite-pegmatite complexes and high-grade regional metamorphic terranes of much greater extent than those of earlier plutonic suites because they were produced by high heat flow over broad crustal regions.

Pegmatite dike swarms pervade Crazy Basin granite and the Southern Bradshaw Mountains Migmatite Complex to the south, but are minor to the north near Cleator, even though metamorphic grades are high and amphibolite facies extends throughout the Crown King-Turkey Creek region. The first amphibolite isograd lies 7 km north of the Crazy Basin contact, the second lies nearly 5 km north, and staurolite first appears 3.5 km north of the contact. Within 100-200 m of the Crazy Basin contact, sillimanite is prograded from andalusite in lineated pelitic gneisses. The absence of cordierite and the presence of staurolite throughout the Cleator metasediments indicate that the Crazy Basin metamorphism was an intermediate-pressure facies (DeWitt, 1976).

The Crazy Basin staurolite-andalusite metamorphic suite is a higher pressure facies than the low-pressure, cordierite-andalusite facies developed around the Horse Mountain monzogranite to the west (Anderson, 1986). Because the plutons are relatively close neighbors, this pressure difference cannot reflect emplacement at different crustal depths at the same time, and therefore must indicate two separate metamorphic events at different times: the lower pressure Horse Mountain series was first and was later overprinted by the higher pressure Crazy Basin series.

This timing is confirmed by textural differences in the metamorphic aureoles of each pluton: the Horse Mountain pluton produced synkinematic textures, whereas the Crazy Basin body produced postkinematic overgrowths of hornblende on earlier deformed fabrics in its northern aureole. Such late-kinematic and postkinematic textures convincingly demonstrate that emplacement of the Crazy Basin body and growth of its thermal aureole occurred after the main events of regional deformation and low-grade metamorphism of the Prescott volcanic belt. Nearly synkinematic metamorphic fabrics closer to the Crazy Basin contact show that continued deformation was localized near the body in response to its rise and thermal metamorphic peak [see Part 4]. Thus, emplacement of the Crazy Basin granite closely followed the major regional deformation of the Prescott volcanic belt.

Metapelites in the Southern Bradshaw Mountains Migmatite Complex were metamorphosed under the same high-temperature, intermediate-pressure facies series as the Crazy Basin granite. Sillimanite-bearing assemblages, locally with andalusite or staurolite, occur in the Silver Mountain region to the south, in contrast to cordierite-bearing assemblages related to the earlier Minnehaha Granodiorite.

An important difference between the southern and northern areas is that upper amphibolite facies metamorphism was of much wider regional extent to the south. The first sillimanite isograd in the north lies at the Crazy Basin contact, but in the south lies up to 3 km from the edge of the migmatite complex. The second sillimanite isograd (muscovite-K-feldspar) is absent in the north, but occurs near the edge of the migmatite complex to the south, indicating that anatectic conditions must have been widespread throughout the Southern Bradshaw Mountains Migmatite Complex. This last conclusion explains the abundance throughout the complex both of granite with eutectic minimum compositions and of partly fused migmatitic paragneiss closely resembling granite.

In summary, all pretectonic and early syntectonic plutonic bodies in the Prescott region (groups 1, 2, and 3) were emplaced under low-pressure, moderate-temperature

Table 1. Field classification of plutonic rocks in the Bradshaw Mountains-Prescott region based solely upon their crosscutting relations, petrographic similarities, and differences in deformational state, as observed in the field (P. Anderson, 1986). Petrologic descriptions of the same plutonic groups are given in table 2.

| | |
|---|---|
| ***Earliest (synvolcanic and intervolcanic) gabbro and gabbro-diorite plutons*** | |
| **Gabbros** | **Gabbro-diorites** |
| gabbro-pyroxenites of Groom Creek | Lynx Creek gabbro-diorites |
| Dandrea Ranch gabbro | gabbro-diorite of Badger Mountain |
| gabbro-pyroxenites near Cordes | gabbro-diorites near Cordes |
| gabbro of Spruce Mountain | gabbro-diorite of West Spruce Mountain |
| Bluebell Mine gabbro | gabbro-diorites in Indian Hills |
| Towers Mountain gabbro | gabbro-diorites northeast of Mayer |
| Silver Spring Gulch Diabase | gabbro-diorites in Grapevine Gulch Fm |
| ***Early (pretectonic) coarse-grained tonalite-granodiorite plutons and batholiths*** | |
| (a) strongly deformed | — Cherry Springs batholith, southern parts (Bumblebee granodiorite, diorite-tonalite of Little Squaw Creek); |
| | — Brady Butte Granodiorite |
| (b) weakly deformed | — Cherry Springs batholith, northern and central parts (tonalite of Cherry, Badger Springs Granodiorite, quartz diorite near Turret Peak) |
| | — Government Canyon Granodiorite |
| (c) deformed and diked | — Wilhoit Granodiorite batholith |
| | — Minnehaha Granodiorite |
| | — Crooks Canyon Granodiorite |
| ***Middle (syntectonic, late-tectonic) fine-grained granodiorite-monzogranite plutons*** | |
| Nonporphyritic (with dike swarms and migmatite) | — Prescott Granodiorite (intrudes Wilhoit Batholith) |
| | — monzogranite of Williams Peak (intrudes Wilhoit) |
| | — Johnson Flat Monzogranite (intrudes Crooks Canyon) |
| | — Longfellow Ridge Monzogranite (intrudes Crooks Canyon) |
| Porphyritic in part | — Skull Valley Monzogranite (intruded by Iron Springs) |
| ***Late (late-tectonic) felsic (mainly monzogranite) plutons and batholiths*** | |
| (a) **Porphyritic** | |
| Yarnell Granodiorite and porphyritic monzogranite (intrudes Wilhoit) | |
| porphyritic monzogranite of Horse Mountain (intrudes Minnehaha) | |
| Iron Springs Porphyritic Monzogranite (intrudes Skull Valley Monzogranite) | |
| (b) **Nonporphyritic, migmatitic** | |
| Crazy Basin Quartz Monzonite (actually granite) | |
| Southern Bradshaw Mountains Migmatite Complex | |
| ***Posttectonic 1400-Ma felsic plutons*** | |
| (a) **Nonporphyritic** | |
| Dells Granite (intrudes Prescott Granodiorite and Iron Springs body) | |

cordierite-andalusite facies metamorphic conditions, whereas the late-tectonic plutons, anatectites, and related migmatite complexes (group 4) formed under higher P-T conditions of an intermediate-pressure, high-temperature, staurolite-andalusite-sillimanite facies. The key factors controlling such differences are the depth of plutonic emplacement and the timing of emplacement relative to the major regional deformation and metamorphism.

## PROTEROZOIC PLUTONIC EVOLUTION

The order in which plutonic suites have been described and are shown in tables 1 and 2 is close to their emplacement order. Field evidence indicates that members of some suites were emplaced so closely in time that their isotopic ages will probably be indistinguishable, but isotopic-age differences between other suites can be distinguished. The Cherry Springs batholith is an exception, because it contains plutonic phases closely related in petrogenesis, but differing in age by as much as 20 m.y. (Bowring, 1986). The total emplacement interval of all plutonic rocks in the Prescott region was approximately 100 m.y. Because only a few key plutonic bodies have been isotopically dated, it is not yet possible to accurately describe Proterozoic plutonic evolution of the region with existing isotopic data. Consequently, the sequence of plutonic, metamorphic, and tectonic events presented herein is based primarily on the detailed relative chronology of P. Anderson (1986) and this paper. The few available isotopic ages of plutons are used as reference points with which to place this relative chronology into an absolute time framework.

### 1800- to 1740-Ma PRETECTONIC PLUTONIC ROCKS

The first primitive magnesian basaltic flow sequences were extruded onto the deep ocean floor from low-K bimodal tholeiitic volcanic centers that evolved in an

Table 2. Petrologic classification of plutonic rocks in the Bradshaw Mountains-Prescott region using petrologic and major-element chemical criteria. "P-C" denotes petrology and chemistry and "P-G" denotes petrogenesis. Examples of each granitic type are found in table 1 and are listed in this table for all but the Group 1 category.

***GROUP 1: Earliest, synvolcanic, mafic plutons and subvolcanic feeders***

(a) **older gabbroic bodies:**

P-C: magnesian pyroxenite; magnesian to calcic gabbro and microgabbro; low-K to intermediate-K tholeiitic diabase; minor high-Na calcic gabbro and gabbroic anorthosite: on magnesian and iron-rich tholeiitic differentiation trends.

P-G: Derived directly from olivine tholeiite source magmas without fractionation or liquid-crystal separation, and from quartz tholeiite source magmas fractionated from olivine tholeiite parents.

(b) **younger gabbro-diorite bodies:**

P-C: calcic, ophitic gabbro-diabase; low-K calc-alkaline gabbro-diorite; differentiated gabbro-diorite-granodiorite; in situ plagioclase-pyroxene segregation related to vapor activity: early pyroxene-dominated cotectic crystallization and late plagioclase-dominated eutectic crystallization; on true iron-rich tholeiitic and low-K calc-alkaline differentiation trends.

P-G: Derived from quartz tholeiite source magmas or pyroxene-gabbro parent magmas with extensive in situ fractional crystallization from volatile activity towards leucogranodiorite end product.

***GROUP 2: Early, pretectonic biotite-hornblende tonalite and granodiorite plutons and batholiths***

(a) **gneissic biotite granodiorite**

examples: Brady Butte granodiorite, Crooks Canyon granodiorite

P-C: gneissic, relatively leucocratic, calc-alkaline, biotite granodiorite, hornblende-deficient, minor muscovite from subsolidus biotite reaction; sub-pyroxene feldspar-dominant cotectic crystallization.

P-G: only in volcanic belt and genetically linked to its evolution; derived from differentiated hydrous calc-alkaline dacitic magmas.

(b) **I-type hornblende-biotite granodiorite and tonalite**

examples: Government Canyon granodiorite, Wilhoit and Minnehaha granodiorites, Cherry Springs batholith

P-C: typical non-porphyritic, I-type hornblende-biotite tonalite and granodiorite with mafic diorite-quartz diorite border phases and mafic xenoliths of igneous source material: on calcic and low-K calc-alkaline differentiation trends, plagioclase zoning during fractional crystallization; batholiths and plutons internally zoned with differentiated felsic phases in cores, early mafic border phases.

P-G: hydrous quartz tholeiite source magmas derived from fusion of earlier igneous crustal material, fractionated during emplacement and upward rise.

***GROUP 3: Middle (syn- and late-tectonic) leucocratic granodiorite and monzogranite plutons and dike swarms***

examples: Prescott, Johnson Flat, Longfellow Ridge, Skull Valley, and Williams Peak granodiorite-monzogranites

P-C: biotite (± muscovite), relatively leucocratic fine-grained granodiorite and monzogranite; metaluminous high-K calc-alkaline, feldspar cotectic crystallization; all in the high-grade-metamorphic roots of the Prescott volcanic belt now exposed on the southwest edge of the Bradshaw Mountains.

P-G: Felsic magmas derived from anatexis of lower crustal volcanic and sedimentary rocks; generically related dike swarms governed by controlling stress field during emplacement.

***GROUP 4: Late (late-tectonic) porphyritic monzogranite-granite plutons, anatectic complexes, and dike swarms***

(a) **Porphyritic**

examples: Iron Springs Monzogranite, Yarnell Granodiorite-monzogranite, Horse Mountain Porphyritic Monzogranite

P-C: High-K calc-alkaline, locally alkali-calcic, porphyritic monzogranite and granite; K-feldspar-dominant cotectic crystallization from near minimum-melt compositions; late dike swarms in hydrous core phases.

P-G: mobilized from ultrametamorphic regions of high heat flow, separated and fractionally crystallized as feldspar-crystal-rich zoned magma chambers.

(b) **Non-Porphyritic**

examples: Crazy Basin Quartz Monzonite, Southern Bradshaw Mountains Migmatite Complex

P-C: High-K calc-alkaline granite-monzogranite with gneissic leucocratic and pegmatitic late phases; eutectic-dominant crystallization from minimum-melt compositions.

P-G: Derived by fusion of paragneiss in zones of high heat flow; crystallized in situ or mobilized from anatectic migmatite complexes.

intraoceanic setting at 1800 to 1780 Ma. Concurrently, the first mafic gabbro suite was emplaced primarily in a hypabyssal environment beneath the volcanic edifices. The Proterozoic crust was geochemically primitive at this early stage, being rich in Mg, Fe, Ca, and Na, and depleted in Si, Al, and K, and the gabbro bodies reflect that primitive chemistry. The subvolcanic gabbro lopoliths caused almost no contact metamorphism and were not diapiric, but they caused extensive Mg-Fe metasomatism of felsic volcanic host rocks.

Continued volcanic activity between 1780 and 1770 Ma thickened the tholeiitic pile to a point where mafic gabbro-diorite plutons rose diapirically into the upper volcanic and clastic units just below the seawater interface. The calcic-series gabbro-diorite bodies caused minor contact-metamorphic effects at deeper levels, but only metasomatism and assimilation at higher levels.

The interval 1770 to 1755 Ma was dominated by depositional hiatuses in places and extrusion of thick trimodal basalt-dacite-rhyolite sequences of Fe-rich calcic chemistry in the center of the volcanic belt. Many mafic centers are cored by gabbroic masses that are the crystallized remains of volcanic feeder necks and subvolcanic magma chambers. These gabbro feeders postdate the

earliest gabbros, are coeval with their 1765-Ma volcanic host rocks, and are close in age to the gabbro-diorite bodies to the west, but are included on table 1 with synvolcanic gabbros because of similarities in petrology and tectonic setting.

By 1750 Ma the volcanic belts had thickened sufficiently to sustain the first suite of calc-alkaline granodioritic plutons. The western Government Canyon body was emplaced at about 1750 Ma into a mafic tholeiitic crust, so its chemistry is most like an I-type granitoid. The Crooks Canyon and Brady Butte bodies were emplaced at about 1750 Ma into a more evolved felsic crust to the east, so are more leucocratic in composition, lying on higher K, calcic to calc-alkaline trends. Metamorphic effects of the plutons were restricted to narrow thermal aureoles not exceeding greenschist facies, except in enclaves. Their emplacement caused local deformation of host rocks near contacts, as well as gentle warping of the volcanic pile, which in turn gave rise to differential erosion and the subsequent development of intervolcanic unconformities.

About 10 m.y. after emplacement of the first granodiorites, after the Prescott-Jerome volcanic belt had built itself southeastward, sequential intrusion of several plutonic phases into this southeast edge culminated in emplacement of the huge Cherry Springs batholith at 1740 Ma. Earliest phases were pyroxene-hornblende tonalite, diorite, quartz diorite, and gabbro, and later phases were more evolved hornblende-biotite granodiorite and tonalite. The quartz diorite of Cherry and other intrusions east of Mayer appear to have been emplaced first, followed by the central Bumblebee-Badger Springs Granodiorites and quartz diorite near Turret Peak, and then by southern mafic phases, such as the tonalite-diorite of Little Squaw Creek. Significantly later, the Bland tonalite and possibly other southern phases were emplaced at about 1720 Ma, closer to the time of regional deformation.

Southeast border diorite phases of the Cherry Springs batholith formed extensive contact-metamorphic and migmatitic zones and caused local anatexis of host rocks in the Little Squaw Creek Migmatite Complex. Northern granodiorite-quartz diorite phases of the batholith, as well as the later Bland phase, intruded tholeiitic to calc-alkaline mainly felsic volcanic-subvolcanic units, producing sharp nonmigmatitic contacts and causing narrow metamorphic aureoles that were later attenuated in the Black Canyon and Shylock tectonic zones.

Emplacement of the Cherry Springs, the first major batholith in the Proterozoic crust of central Arizona, indicates that by 1740 Ma (only 50 m.y. after inception) formative volcanism had ceased and the volcanoplutonic belt was thick enough to sustain major batholiths. Batholithic emplacement caused local deformation and metamorphism of host rocks, including uplift and stripping off of cover material, but major deformation of the belts was yet to come.

Southwest of the Prescott volcanic belt, a similar plutonic evolution is recorded. The earliest Wilhoit Granodiorite batholith was emplaced at about 1740 Ma and was fractionally derived from sources like that of the Government Canyon Granodiorite. The Minnehaha Granodiorite was also emplaced at about the same time, but does not show the compositional and structural zoning typical of the Wilhoit and Cherry Springs batholiths. All these early granodiorite plutons and batholiths are chemically much alike: except for slight alkali enrichment, they are normal metaluminous, subalkaline calcic hornblende-biotite I-type granodiorites with enclaves of lower crustal, mafic dioritic source material.

## 1730- to 1710-Ma SYNTECTONIC PLUTONIC ROCKS

Plutonism in the central Arizona Proterozoic crust prior to 1730 Ma occurred in a static pretectonic environment, but after 1730 Ma the structural setting of the entire volcano-plutonic arc changed toward intensified deformation as later batholiths and plutons were emplaced. All post-1730-Ma plutons are thus syntectonic or late tectonic, depending on their emplacement timing. During this same period, Texas Gulch Formation successor clastics were laid down in downwarped troughs, and incorporated eroded remnants of pretectonic plutonic rocks. The time span from the first signs of deformation to the last in this part of central Arizona was almost 30 m.y., but deformation was intermittent or spasmodic during that period, locally amplified in each area by pluton emplacement.

Post-1740-Ma syntectonic plutonic rocks were influenced both in external shape and internal fabrics by a stress field dominated by vertical tectonic transport sympathetic to northwest-southeast compression. As a result of such stress, intruding plutons became elongate northeast-southwest and assumed a pervasive northeast-trending foliation of variable intensity and structure. Not only did these syntectonic plutons mirror the deformational field, but the locations and trends of dike swarms they produced were also dictated by the stress field as the dikes invaded and migmatized the deforming host rocks.

From 1730 to 1710 Ma, peaking at 1720 Ma, syntectonic granodiorite-monzogranite plutons intruded the Prescott-Jerome volcanic belt at depth, and are now exposed along its west and southwest sides. The Johnson Flat and Longfellow Ridge bodies are enveloped by screens of deformed, metavolcanic-metasedimentary rocks migmatized by dikes from the plutons. The Prescott Granodiorite, monzogranite of Williams Peak, and their dike swarms intruded mainly the Wilhoit batholith and its host rocks. Unlike the earlier I-type Wilhoit and Minnehaha bodies, the felsic, low- to moderate-K calc-alkaline chemistries of these syntectonic plutons, with crystallization starting in the feldspar fields near eutectic compositions, suggest an origin by lower crustal anatexis of volcanoplutonic arc or oceanic crust.

A later plutonic event near 1710 Ma produced the first plutons of truly K-rich calc-alkaline character, with crystallization originating in the K-feldspar field. These

plutons are weakly peraluminous K-feldspar porphyritic monzogranites with local K-rich calc-alkaline granodiorite borders, and include the Yarnell, Iron Springs, and Horse Mountain bodies. The high fluid content of the Horse Mountain body produced pegmatite dike swarms and a wide amphibolite aureole whose low-pressure, moderate-temperature, cordierite-andalusite facies series is diagnostic of the syntectonic plutons and their rather shallow crustal emplacement levels.

## 1700-Ma LATE-TECTONIC PLUTONIC ROCKS

By 1700 Ma, most intervolcanic crust outside the main core of the Prescott-Jerome volcanic belt had been pervaded, assimilated, migmatized, or replaced by various calc-alkaline plutons, and all volcanic, sedimentary, and plutonic rocks had been deformed by penetrative foliation and lineation. In places, such as near Prescott, the total strain state of the volcanoplutonic crust was mild, but in others such as in the Shylock high-strain zone, total strain was extreme. Only the most massive, competent volcanic and plutonic rocks, or those shielded from strain, escaped penetrative deformation.

At about 1700 Ma, middle crustal levels now exposed southwest and south of the Prescott belt underwent high-grade metamorphism of truly regional ($> 300\text{-km}^2$) extent as the thermal infrastructure of the crust rose in response to increased heat flow. Most of the southern Bradshaw Mountains became a region of large-scale crustal fusion, where intermediate-pressure, high-temperature, staurolite-andalusite-sillimanite metamorphic facies series prevailed, reflecting P-T conditions of 10- to 15-km lithostatic depth and temperatures exceeding granite-minimum anatexis. The Southern Bradshaw Mountains Migmatite Complex was the source region for in situ, anatectic formation of granite in the complex.

Some anatectite diapirically rose to be emplaced to the north as the high-silica, K-rich, calc-alkaline Crazy Basin granite and related leucogranites. Earlier tectonic fabrics in host rocks were thermally overprinted, deformation and vertical extension were intensified at the Crazy Basin's top in response to its rise, and high fluid flow around the body retrograded many metamorphic assemblages as the thermal complex cooled. So ended mid-Proterozoic plutonic orogeny in this part of central Arizona at approximately 1700 Ma.

The 1700-Ma Crazy Basin-Southern Bradshaw Mountains Migmatite Complex anatectic event occurred at depth as felsic volcanic and sedimentary rocks were being laid down at surficial crustal levels in the younger felsic volcanic belts to the southeast (New River-Cave Creek-Mazatzal Mountain-Diamond Butte areas). Because this anatectic event was the last stage in deformation and metamorphism of the Prescott-Jerome volcanic belt, and because its metamorphic fabrics were overprinted on tectonic fabrics of the main Prescott-Jerome deformation, it is clear that major deformation of the Prescott-Jerome belt must have occurred before deformation of the younger felsic volcanic belts, because the youngest 1700-Ma Mazatzal Group strata in those younger belts are deformed by the later deformation. Thus, the formation of the Crazy Basin-Southern Bradshaw Mountains migmatite zone demonstrates that two separate deformational events occurred in central Arizona [see tectonics paper].

## ORIGINS AND SOURCES OF THE PLUTONIC SUITES

Data cited throughout this paper indicate that there is a close correlation between the chemistries of plutonic rocks and the general composition of their host crusts. This correlation clearly does not imply that plutonic rocks were derived from their immediately adjacent host rocks, because such rocks are hosts only at present emplacement levels, not in the source regions. However, the correlation does imply that the broad distribution of crustal compositions throughout central Arizona profoundly influenced, directly or indirectly, the plutonic compositions that were derived from or emplaced into each host crust.

All formative volcanic sequences of the Prescott-Jerome belts and distal sediments had been deposited before granodioritic plutonism invaded the volcanic belts and adjacent regions (only synvolcanic gabbros and intervolcanic gabbro-diorites were coeval with formative volcanic units). The lithologic makeup of the early volcanoplutonic crust was highly variable, depending on the distribution of primitive volcanic sequences versus more evolved crustal components. This original variability profoundly influenced the nature of all subsequent plutonism, as is clearly shown in figure 17, a diagram that maps crustal variability and evolution as the volcanic belt was transformed into a thickened, stabilized volcanoplutonic arc.

The oldest, most primitive part of the Prescott volcanic belt is its northwest edge near Prescott, but mafic components also exist along its east edge near the Jerome volcanic belt and as remnants in the Cherry Springs batholith. The earliest plutons emplaced into that mafic crust to the west had the highest Sr and Fe contents of all: both the Government Canyon Granodiorite and the Wilhoit batholith are the most primitive of all granodiorite-tonalite plutons, with the highest Sr contents (and lowest initial Sr ratios), highest Sr-Fe ratios, and highest values in other basic elements such as Ca and Mg. The Cherry Springs batholith was emplaced into a slightly more evolved crust, and shows exactly that difference on figure 17. Differentiation within the early bodies such as the Wilhoit batholith was along typical iron-rich tholeiitic trends (fig. 17).

Other early small plutons, such as the Brady Butte and Crooks Canyon, were derived from and emplaced into a more geochemically evolved felsic crust than were the

Government Canyon, Wilhoit and Cherry Springs bodies, and this difference is precisely reflected in their lower Sr and Fe contents (fig. 17). Similarly, the character of host crust in the Black Canyon belt southeast of the Prescott belt's main volcanic core is more felsic and evolved than in the north near Mingus Mountain, and this difference is reflected not only in the lower Sr and Fe contents of south-central Cherry Springs batholith phases (Bumblebee, Badger Springs and Little Squaw Creek) versus northern (Cherry quartz diorite and related) phases, but also in the different differentiation trends of little or no Sr enrichment in the south versus strong Sr enrichment in the north (fig. 17).

One of the most important aspects of crustal evolution (fig. 17) is that the younger plutons subsequently emplaced into these diverse crusts in syntectonic and late-tectonic settings do not have chemistries unique to the later events. Rather, their chemistries reflect the same source composition as do previous plutons emplaced into the same region (fig. 17). The Prescott Granodiorite was derived from and emplaced into the same Sr-rich crust as were the Wilhoit and Government Canyon bodies, and shares their Sr-rich source on figure 17, but with a typical younger calc-alkaline fractionation trend of no Fe enrichment. The Yarnell, Horse Mountain, and Skull Valley bodies are endemic to evolved felsic crusts with little mafic volcanic component, and are similar in composition to older plutonic rocks emplaced into the same low-Sr, low-Fe crust. The Bland tonalite is chemically like other southern phases of the Cherry Springs batholith, lying along the same trend of no Sr enrichment (fig. 17), even though it is 20 m.y. younger.

The Iron Springs and Johnson Flat plutons were emplaced at the edges of mafic volcanic regions and consequently have geochemical characteristics transitional between the other two populations. Even the latest Crazy Basin body, derived from anatexis of an essentially sedimentary crust south of the Bradshaw Mountains, plots in the lowest Fe-Sr part of figure 17, which suggests that its chemistry also directly reflects the composition of its sedimentary source crust. Other major and trace elements can be used as a basis for comparisons similar to those made here, and the same overall conclusion is apparent: *the chemical composition of the host (or source) crust governs the composition of all plutonic rocks emplaced into that crust, regardless of age of the plutonic rocks.*

Because host rocks at pluton-emplacement levels cannot be the sources of the plutonic bodies, only one possible conclusion remains. The general character of the underlying crust must have governed the compositions of the plutons, and therefore these plutons must have been derived by partial melting of that lower crust. Thus, a model of partial melting of the base of the volcanic-arc crust must be endorsed as most viable to account for the remarkably close correlation between pluton and host crust compositions in the older volcanic belts and adjacent region of central Arizona. The minor- and trace-element profiles of the plutonic rocks precisely mirrored the composition of the lower crust of the volcanic arc, even if some major fractional elements such as K and Na do not.

This evidence for lower crustal anatexis is inconsistent with models that assume that the material input to an arc came from either subducted oceanic crust or the mantle immediately subjacent to the arc crust. In the central volcanic belt, such models may be viable for generation of island-arc volcanic rocks, but they are quite inapplicable to generation of the plutonic components. Those plutonic components must have involved recycling of the earlier volcanic crust and its oceanic substratum, especially those portions that were subject to the deepest burial and most extensive fusion. In contrast, part of the alkali and vapor components of fusion must have been contributed by the subduction process, because the plutonic suites of the Prescott region have alkali contents that generally increase to the northwest, in part irrespective of alkali contents of their host crusts. This northwesterly increase in alkalis corresponds to the northwest dip of a subducted paleoslab, whose thermal structure was largely responsible for generating plutonic rocks of the Prescott region [see tectonics paper].

## PART 4—PROTEROZOIC VERTICAL DEFORMATION AND ITS TECTONIC SIGNIFICANCE

Proterozoic volcanic belts throughout the world exhibit a distinctive style of deformation characterized by (1) pervasive vertical to steeply dipping foliation, (2) vertical and steeply plunging lineations and minor folds, (3) great lateral variations in strain, and (4) a lack of polyphase deformation at low metamorphic grades. Although Archean deformation appears similar, parts of Archean greenstone belts are pervaded by shallow-plunging lineations, obvious polyphase deformation, and other features distinctively *not* Proterozoic. Deformation of Phanerozoic island arcs is dominated by features of horizontal transport (major overthrust stacking, subhorizontal axes and lineations), which are even more unlike Proterozoic features. Consequently, Proterozoic deformation needs elucidation in its own right, not by analogy to the Phanerozoic or Archean, as such analogies have caused

migrated into the trough, and confirm the predominance of synclinal keels in the volcanic troughs without complementary anticlines. The interested reader is referred to this classic paper for further information on vertical deformation.

## CONCLUSIONS

Evidence overwhelmingly indicates that steep to vertical structures in central Arizona Proterozoic volcanic belts were produced by a single major event of deformation without first forming subhorizontal fabrics and rotating them to vertical. This does not require deformation in all parts of central Arizona to be exactly synchronous, because there is clear evidence that deformation in the Prescott region predated that in eastern volcanic belts [see tectonics paper], nor does it preclude local superimposed folding at sites where the strain regime changed substantially during progressive deformation. Formation of vertical fabrics in one event *does* mean that vertical deformation proceeded under a single stress regime, of highly variable strain, and that the terrane was not first deformed under one stress regime, then later redeformed under a different stress regime, as in polydeformed regions throughout the world.

Because of their primary lensoidal makeup, Proterozoic volcanic piles became *dominantly deformed terranes, not folded terranes,* so major closures of volcanic stratigraphy around regional folds do not exist, and bedding did not originally trend northwest perpendicular to foliation. Instead, the original northeast-trending depositional troughs helped guide the orientation of foliation. Folds internal to major units were best developed at moderate to low strain, in well-bedded strata, and where bedding locally diverged from regional foliation.

This study defines and describes in detail *high-strain zones* that developed in the volcanic belts at all scales, the largest marking the axes of strongest vertical extension in them. High-strain zones are integral parts of vertical deformation and represent zones where foliation and lineation are much more intensely developed than in adjacent areas. In places (e.g., Sheep Basin Mountain "horseshoe fold") it can be documented how rock units were drawn down toward keels of the zones by extreme vertical extension to produce structures resembling refolded folds in plan view. Intense foliation was not synonymous with offset: in fact a key aspect of high-strain zones is a dominance of pure shear vertical extension over simple shear; hence they are different from shear zones with major offset. Distributed vertical strain may change to shear offset where high-strain zones cut through granitic masses along strike (e.g., Moore Gulch shear zone). Changing simple shear component along strike is compensated for by ductile behavior and does not imply scissor or rotational motion.

Another key feature of Proterozoic high-strain zones is their widening and strain distribution with depth. At surface they resemble vertical faults (Deadman Wash), at high crustal levels they are narrow (Shylock zone), but at deeper crustal levels strain is more widely distributed (Black Canyon belt). This is the opposite of many shear zones and thrusts that narrow and become cryptic with depth; competency changes govern where high-strain zones become cryptic. Distributed vertical strain at depth was thus manifested as offset on vertical faults as zones surfaced. Finally, all high-strain zones in central Arizona show complex histories of typically an early event of vertical pure shear, later superimposed by simple shear offset as deformation progressed to more ductile conditions, and finally either oblique slip or brittle vertical normal faulting after deformation.

Stratigraphy of the central volcanic belt was never oriented to vertical prior to deformation and large overturned or recumbent sections are not known. In most parts of the belts, the original way up is still up, both regionally and in detail. Thus, stratigraphy kept its proper context during deformation, and broad-scale geologic relationships of the belts are preserved. The original question posed at the beginning of this paper—"how was the stratigraphy oriented to vertical in the first place?"—is therefore reduced to the mechanistic question of "how, kinematically, can vertical fabrics be imposed upon a horizontal sequence?." This paper has answered that question.

The strain analysis presented in this paper shows how the structures of Proterozoic vertical deformation started in moderate to steep attitudes as strain reaches certain threshold levels that allow each feature to be expressed, then increased pure shear strain beyond those levels progressively distorted all features, including foliation, bedding, lineations, primary features, and folds, to vertical at maximum degrees of horizontal shortening and vertical extension. The analysis also shows that the axial ratios of distorted features, foliation intensity, and both intensity and steepness of lineations are the best measures of strain and its variations throughout the volcanic belts. Fold models and stereographic analyses fail to develop a similarly accurate strain picture.

Deformation penetrated vertical zones of weakness in the volcanic pile first, causing high strain in them before adjacent, more competent units took up significant strain. It is entirely possible that the earliest fabrics in these high-strain zones originated in near-vertical attitudes from the outset, because of extremely fissile response to strain and initially large contrasts in magnitude of strain imposed on them. Therefore, regardless of whether the total net strain was weak or strong, *the geometry of features such as lineation and folds that formed in response to strain remained approximately constant throughout the history of strain.* This means that lineations originated with shallow to moderate plunges in some places, and with steep plunges in others, depending on the kinematics of strain at each locality. In other areas near the edges of the volcanic belt, simple-shear strain clearly rotated structures toward vertical during progressive deformation, and where strain

progressed to extreme degrees in some high-strain zones, rock fabrics became extended or "drawn out" by simple shear, and major vertical dislocations resulted.

This presents essentially an instantaneous strain model for deformation of Proterozoic volcanic belts. Changes in plate motions are geologically instantaneous events that can turn on or off the forces that are the essential driving mechanism behind horizontal shortening of the crust and the deformation that results from it. Hence it is entirely realistic to predict instantaneous strain response to stress. The reason this paper considered only strain in the volcanic belts and not causative stresses is because stress is imposed on the crust over a scale much broader than the volcanic belts, and is ultimately linked to plate tectonic interactions at the accreting Proterozoic continental margin [see tectonics paper]. On this very broad scale, *the volcanic belts passively absorb strain* as the competent batholithic masses around them shear and readjust to produce the most efficient crustal shortening possible. Much adjustment involves density compensation, whereby lighter plutonic rocks rise as denser rocks of the volcanic belts deform downward into synclinal troughs and keels. The volcanic belts thus invariably shorten in all horizontal directions, not just one direction, and as a result, the direction of material transport in the belts is vertical. *Proterozoic vertical deformation* accurately describes this vertical motion.

Possibly the most profound aspect of Proterozoic vertical deformation is that the structural fates of the volcanic belts were sealed before they were ever deformed. Ultimately it was the original stratigraphic makeup of the volcanic belts—their thick domal volcanic edifices and intervening zones of crustal weakness, the disposition of pretectonic batholiths around them, and ancestral bounding fault scarps delimiting original depositional basins—that was to govern how the volcanic belts were to deform. These features alone controlled the great variations of strain within the belts, *variations to which the stress field was completely blind.* Consequently, Proterozoic vertical deformation is not only a unique structural style, it was a necessary part of the tectonic evolution of Proterozoic volcanic belts worldwide, no less fundamental than the primary volcanic makeup of the belts, to which it is inseparably linked in the final analysis. This suggests that perhaps the most sound, enduring structural analysis of Proterozoic volcanic belts should start with a very detailed understanding of their *stratigraphic makeup,* rather than a compass, stereonet, and many, many structural readings.

## ACKNOWLEDGMENT

Both the writer and these papers are greatly indebted to Steve Reynolds, whose unfailing confidence and untiring persistence became the cornerstone of their completion.

## REFERENCES

Aldrich, L. T., Wetherill, G. W. and Davis, G. L., 1957, Occurrence of 1350-million-year-old granitic rocks in western United States: Geological Society of America Bulletin, v. 68, p. 655-656.

Anderson, C. A., 1951, Older Precambrian structure in Arizona: Geological Society of America Bulletin, v. 62, no. 11, p. 1331-1346.

Anderson, C. A., 1966, Areal geology of the Southwest, *in* Titley, S. R., and Hicks, C. L., Geology of the porphyry copper deposits, southwestern North America: Tucson, University of Arizona Press, p. 3-16.

Anderson, C. A., 1968a, Metamorphosed Precambrian silicic volcanic rocks in central Arizona, *in* Coats, R. R., ed., Studies in volcanology—A memoir in honor of Howell Williams: Geological Society America Memoir 116, p. 9-45.

Anderson, C. A., 1968b, Precambrian wrench fault in central Arizona: U.S. Geological Survey Professional Paper 575-C, p. 60-65.

Anderson, C. A., 1968c, Arizona and adjacent New Mexico, *in* Ridge, J. D., Ore deposits of the United States, 1933-1967, Graton-Sales volume: American Institute of Mining and Metallurgical Engineers, Vol. 2, p. 1163-1190.

Anderson, C. A., 1972, Precambrian rocks of the Cordes area, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1345, 36 p.

Anderson, C. A., and Blacet, P. M., 1972a, Geologic map of the Mayer quadrangle, Yavapai County, Arizona: U.S. Geological Survey Map GQ-996.

Anderson, C. A., and Blacet, P. M., 1972b, Geologic map of the Mount Union quadrangle, Yavapai County, Arizona: U.S. Geological Survey Map GQ-997.

Anderson, C. A., and Blacet, P. M., 1972c, Precambrian geology of the northern Bradshaw Mountains, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1336, 82 p.

Anderson, C. A., Blacet, P. M., Silver, L. T., and Stern, T. W., 1971, Revision of the Precambrian stratigraphy in the Prescott-Jerome area, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1324-C, p. C1-C16.

Anderson, C. A., and Creasey, S. C., 1958, Geology and ore deposits of the Jerome area, Yavapai County, Arizona: U.S. Geological Survey Professional Paper 308, 185 p.

Anderson, C. A., and Creasey, S. C., 1967, Geologic map of the Mingus Mountain quadrangle, Yavapai County, Arizona: U.S. Geological Survey Map GQ-715, scale 1:62,500.

Anderson, C. A., Scholz, E. A., and Strobell, J. D. Jr., 1955, Geology and ore deposits of the Bagdad area, Yavapai County, Arizona: U.S. Geological Survey Professional Paper 278, 103 p.

Anderson, C. A., and Silver, L. T., 1976, Yavapai Series—a greenstone belt: Arizona Geological Society Digest 10, p. 13-26.

Anderson, Phillip, 1976, Proterozoic convergent plate tectonics: Sydney, Australia, 25th International Geological Congress Abstracts, v. 1, p. 73.

Anderson, Phillip, 1977, Massive sulfides deposits applied to problems of Precambrian stratigraphy in Arizona—discussion: Economic Geology, v. 72, p. 110-111.

Anderson, Phillip, 1978a, The island arc nature of Precambrian volcanic belts in Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 10, no. 3, p. 156.

Anderson, Phillip, 1978b, Precambrian basement structure of the Cordilleran margin, Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 10, no. 3, p. 93.

Anderson, Phillip, 1980, Regional time-space distribution of porphyry deposits—a decisive test for the origin of metals in magma-related ore deposits, *in* Ridge, J. D., ed., Proceedings of the Fifth International Association on the Genesis of Ore Deposits Symposium: Stuttgart, E. Schweizerbartische Verlagsbuchhandlung, v. 1, p. 35-48.

Anderson, Phillip, 1986, The Proterozoic tectonic evolution of Arizona: Tucson, University of Arizona, unpublished Ph. D. dissertation, 416 p.

Anderson, Phillip, n. d., The tectonic evolution of Arizona's Proterozoic crust: Payson, Arizona, PRI Publishing (in prep.).

Anderson, Phillip, and Guilbert, J. M., 1979, The Precambrian massive sulfide deposits of Arizona—A distinct metallogenic epoch and province: Nevada Bureau Mines and Geology Report 33, p. 39-48.

Anderson, Phillip, and Wirth, K. R., 1981, Uranium potential in Precambrian conglomerates of the central Arizona arch: U.S. Department of Energy Report GJBX-33(81), 576 p.

Beard, L. S., 1985, Precambrian geology of the Cottonwood Cliffs area, Mohave County, Arizona: Tucson, University of Arizona, unpublished M.S. thesis, 115 p.

Blacet, P. M., 1966, Unconformity between gneissic granodiorite and overlying Yavapai Series (older Precambrian), central Arizona: U.S. Geological Survey Professional Paper 550-B, p. 1-5.

Blacet, P. M., 1968, Precambrian geology of the SE ¼ Mount Union Quadrangle, Bradshaw Mountains, central Arizona: Palo Alto, California, Stanford University, unpublished Ph. D. dissertation, 244 p.

Bowring, Sam, Karlstrom, K. E., and Chamberlain, K., 1986,, U-Pb zircon constraints on Proterozoic tectonic evolution in central Arizona [abs.]: Geological Sociey of America Abstracts with Programs, v. 18, no. 5, p. 343.

Brook, D. K., 1974, Relative ages of stratiform sulfide ore and wall rock determined by structural analysis of the Copper Queen Mine, Yavapai County, Arizona: Tucson, University of Arizona, unpublished M. S. thesis, 60 p.

Brown, E. H., Babcock, R. S., and Clark, M. D., 1974, A preliminary report on the Older Precambrian rocks in the Upper Granite gorge of the Grand Canyon, *in* Karlstrom, T. N. V., Swann, G. A., and Eastwood, R. L., eds., Geology of Northern Arizona, Part 1—Regional studies: Geological Society America, Rocky Mountain Section Meeting, Flagstaff, Arizona, p. 2-33.

Chappell, B. W,. and White, A. J. R., 1974, Two contrasting granite types: Pacific Geology, v. 8, p. 173-174.

Chappell, B. W., and White, A. J. R., 1976, Plutonic rocks of the Lachlan mobile zone: Sydney, Australia, 25th International Geological Congress excursion guide, 40 p.

Clayton, R. L., and Baker, A., III, 1973, Pb-Pb ages of a galena sample from the Bruce Mine, Yavapai County, Arizona: Isochron/West, no. 6, p. 35.

Condie, K. C., 1982, Plate-tectonics model for Proterozoic continental accretion in the southwestern United States: Geology, v. 10, no. 1, p. 37-42.

Conway, C. M., 1976, Petrology, structure, and evolution of a Precambrian volcanic and plutonic complex, Tonto Basin, Gila County, Arizona: Pasadena, California Institute of Technology, unpublished Ph. D. dissertation, 460 p.

Conway, C. M., and Silver, L. T., 1976, Rhyolite-granophyre-granite complex, Tonto Basin, Gila County, Arizona—A deeply exposed Precambrian analog of the Yellowstone rhyolite plateau [abs.]: Geological Society of America Abstracts with Programs, v. 8, no. 5, p. 579-580.

Conway, C. M., Silver, L. T., Wrucke, C. T., and Ludwig, K. R., 1981, Proterozoic Mazatzal quartzite of central Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 13, no. 2, p. 50.

Conway, C. M., and Wrucke, C. T., 1986, Proterozoic geology of the Sierra Ancha-Tonto Basin-Mazatzal Mountains area; Road log and field guide: Arizona Geological Society Digest 16, p. 227-247.

Conway, C. M., Wrucke, C. T., Ludwig, K. R., and Silver, L. T., 1982, Structures of the Proterozoic Mazatzal orogeny, Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 14, no. 4, p. 156.

Creasey, S. C., 1980, New data concerning Proterozoic volcanic stratigraphy and structure in central Arizona and its importance in massive sulfide exploration—discussion: Economic Geology, v. 75, p. 943-944.

Damon, P. E., 1962, How old is the Older Precambrian of Arizona and Sonora?: Journal Geophysical Research, v. 67, no. 4, p. 1634.

Darton, N. H., 1925, A resumé of Arizona geology: Tucson, Arizona Bureau of Mines Bulletin 119, 298 p.

Dewey, J. F., and Spall, H., 1975, Pre-Mesozoic plate tectonics: how far back in Earth history can the Wilson Cycle be extended? [Penrose Conference report by conveners]: Geology, v. 3, no. 8, p. 422-424.

DeWitt, Ed, 1976, Precambrian geology and ore deposits of the Mayer-Crown King area, Yavapai County, Arizona: Tucson, University of Arizona, unpublished M. S. thesis, 150 p.

DeWitt, Ed, 1978, "Massive sulfide" deposits and Proterozoic volcanism in north-central Arizona—a major revision of existing structure and stratigraphy [abs.]: Geological Society of America Abstracts with Programs, v. 10, no. 3, p. 102.

DeWitt, Ed, 1979, New data concerning Proterozoic volcanic stratigraphy and structure in central Arizona and its importance in massive sulfide exploration: Economic Geology, v. 74, p. 1371-1382.

DeWitt, Ed, 1980, New data concerning Proterozoic volcanic stratigraphy and structure in central Arizona and its importance in massive sulfide exploration—Reply: Economic Geology, v. 75, p. 944-945.

Dickinson, W. R., 1975, Potash-depth (K-h) relations in continental margin and intra-oceanic magmatic arcs: Geology, v. 3, p. 53-56.

Dixon, J. M., and Summers, J. M., 1983, Patterns of total and incremental strain in subsiding troughs: experimental centrifuged models for inter-diapir synclines: Canadian Journal of Earth Sciences, v. 20, p. 1843-1861.

Erickson, R. C., 1969, Petrology and geochemistry of the Dos Cabezas Mountains, Cochise County, Arizona: Tucson, University of Arizona, unpublished Ph. D. dissertation, 441 p.

Gastil, R. G., 1953, The geology of the eastern half of the Diamond Butte quadrangle, Gila County, Arizona: Berkeley, University of California, unpublished Ph. D. dissertation, 150 p.

Gastil, R. G., 1958, Older Precambrian rocks of the Diamond Butte quadrangle, Gila County, Arizona: Geological Society of America Bulletin, v. 69, no. 12, p. 1495-1513.

Gastil, R. G., 1962, A working hypothesis for Arizona's Older Precambrian history, in eds. : New Mexico Geological Society, 13th Field Conference Guidebook, p. 52-55.

Goodwin, A. M., 1965, Mineralized volcanic complexes in the Porcupine-Kirkland Lake-Noranda region, Canada: Economic Geology, v. 60, p. 955-971.

Hatherton, T., and Dickinson, W. R., 1969, The relationship between andesitic volcanism and seismicity in Indonesia, the Lesser Antilles, and other island arcs: Journal Geophysical Research, v. 74, p. 5301-5310.

Hedge, C. E., and Stacey, J. S., 1980, Precambrian geochronology of northern Utah [abs.]: Geological Society of America Abstracts with Programs, v. 12, p. 275.

Hills, F. A., and Armstrong, R. L., 1974, Geochronology of Precambrian rocks in the Laramie Range and implications for the tectonic framework of Precambrian southern Wyoming: Precambrian Research, v. 1, p. 213-225.

Hinds, N. E. A., 1938, Pre-Cambrian Arizonan revolution in western North America: American Journal of Science, 5th Ser., v. 35, p. 445-449.

Horikoshi, Ei, 1969, Volcanic activity related to the formation of the Kuroko-type deposits in the Kosaka district, Japan: Mineralium Deposita, v. 4, p. 321-345.

Hutchinson, R. W., Ridler, R. H., and Suffel, G. C., 1971, Metallogenic relationships in the Abitibi belt, Canada: A model for Archean metallogeny: Canadian Institute Mining & Metallurgy Transactions, v. 74, p. 103-115.

Jaggar, T. A., Jr., and Palache, C., 1905, Description of Bradshaw Mountains quadrangle, Arizona: U.S. Geological Survey Atlas folio 126, 11 p.

Jerome, S. E., 1956, Reconnaissance geologic study of the Black Canyon schist Belt, Bradshaw Mountains, Yavapai and Maricopa Counties, Arizona: Salt Lake City, University of Utah, unpublished Ph. D. dissertation, 160 p.

Karlstrom, K. E., 1986, Thrusting and strike-slip faulting during Proterozoic accretion in central Arizona [abs.]: Geological Society of America Abstracts with Programs; v. 18, no. 5, p. 365.

Karlstrom, K. E., Bowring, S. A., and Conway, C. M., 1987, Tectonic significance of an early two-province boundary in central Arizona: Geological Society of America Bulletin, v. 99, p. 529-538.

Karlstrom, K. E., and Puls, D. D., 1984, Geometry of structures in a Proterozoic thrust belt, Mazatzal Mountains, central Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 16, no. 6, p. 554.

Keith, S. B., 1978, Paleosubduction geometries inferred from Cretaceous and Tertiary magmatic patterns in southwestern North America: Geology, v. 6, p. 516-521.

Kessler, E. J., 1976, Rubidium-strontium geochronology and trace element geochemistry of Precambrian rocks in the northern Hualapai Mountains, Mohave County, Arizona: Tucson, University of Arizona, unpublished M. S. thesis, 73 p.

Krieger, M. H., 1965, Geology of the Prescott and Paulden quadrangles, Arizona: U.S. Geological Survey Professional Paper 467, 127 p.

Kuno, H., 1959, Origin of Cenozoic petrographic provinces of Japan and surrounding areas: Bulletin Volcanologique, ser. 2, v. 20, p. 957-1020.

Kuno, H., 1966, Lateral variation of basalt magma type across continental margins and island arcs: Bulletin Volcanologique, v. 29, p. 195-222.

Kuno, H., 1968, Origin of andesite and its bearing on the island arc structure: Bulletin Volcanologique, v. 32, pt. 1, p. 141-176.

Lance, J. F., 1959, Precambrian rocks of southeast Arizona, *in* Heindl, L. A., ed., Southern Arizona Guidebook II: Tucson, Arizona Geological Society, p. 12-15.

Lanphere, M. A., 1968, Geochronology of the Yavapai Series of central Arizona: Canadian Journal Earth Sciences, v. 5, no. 3, pt. 2, p. 763-772.

Lanphere, M. A., and Wasserburg, G. J., 1963, Some ages in the Precambrian of Arizona, Nevada, and Utah [abs.]: Geological Society of America Special Paper 73, p. 45.

Lausen, Carl, 1930, The pre-Cambrian greenstone complex of the Jerome quadrangle: Journal of Geology, v. 38, p. 174-183.

Lindberg, P. A., 1986, An overview of Precambrian ore deposits of the southwestern United States: Tucson, Arizona Geological Society Digest 16, p. 18-23.

Lindgren, Waldemar, 1926, Ore deposits of the Jerome and Bradshaw Mountains quadrangles, Arizona: U.S. Geological Survey Bulletin 782, 192 p.

Livingston, D. E., 1969, Geochronology of Older Precambrian rocks in Gila County, Arizona: Tucson, University of Arizona, unpublished Ph. D. dissertation, 224 p.

Livingston, D. E., and Damon, P. E., 1968, The ages of stratified Precambrian rock sequences in central Arizona and northern Sonora: Canadian Journal of Earth Sciences, v. 5, no. 3, pt. 2, p. 763-772.

Livingston, D. E., and others, 1974, Rb-Sr whole rock isochron ages for "older" Precambrian plutonic and metamorphic rocks of the Grand Canyon, Arizona [abs.]: Geological Society America Abstracts with Programs, v. 6, no. 7, p. 848-849.

Ludwig, K. R., 1974, Precambrian geology of the central Mazatzal Mountains, Arizona: Pasadena, California Institute of Technology, unpublished Ph. D. dissertation, 218 p.

Maynard, S. R., 1986, Moore Gulch fault, SW New River Mountains, Az.: A major Precambrian geochronologic boundary? [abs.]: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 394.

Moores, E. M., 1976, Possible Precambrian ophiolite complex, central Arizona: E.O.S. Transactions, v. 57, n. 12, p. 1027.

More, S. W., 1980, The geology and mineralization of the Antler mine and vicinity, Mohave County, Arizona: Tucson, University of Arizona, unpublished M. S. thesis, 149 p.

Noble, L. F., and Hunter, J. F., 1916, A reconnaissance of the Archean complex of the Granite Gorge, Grand Canyon, Arizona: U. S. Geological Survey Professional Paper 98, p. 95-113.

O'Hara, P. F., 1980, Metamorphic and structural geology of the northern Bradshaw Mountains, Yavapai County, Arizona: Tempe, Arizona State University, unpublished Ph. D. dissertation, 117 p.

O'Hara, P. F., 1986, Stratigraphy and structural geology in the Prescott-Mayer area: Tucson, Arizona Geological Society Digest 16, p. 358-364.

O'Hara, P. F., Yoder, M. P., Stamm, C. A., Niver, Randall, and Maliga, Jody, 1978, The Precambrian Texas Gulch Formation boundary fault system, Yavapai County, Arizona—A folded unconformity? [abs.]: Geological Society of America Abstracts with Programs, v. 10, no. 3, p. 140.

Ohmoto, Hiroshi, and Skinner, B. J., eds., 1983, The Kuroko and related volcanogenic massive sulfide deposits: Economic Geology Monograph 5, 604 p.

Pasteels, P., and Silver, L. T., 1966, Geochronologic investigations in the crystalline rocks of the Grand Canyon, Arizona [abs.]: Geological Society of America Special Paper 87, p. 124.

Puls, D. D., and Karlstrom, K. E., 1986, Proposed names for major thrusts in the northern Mazatzal Mountains, central Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 404.

Ramberg, Hans, 1981, Gravity, deformation and the earth's crust (2nd ed.): London, England, Academic Press, 452 p.

Ramsay, J. G., 1967, Folding and fracturing of rocks: New York, McGraw-Hill, 562 p.

Ramsay, J. G., and Graham, R. H., 1970, Strain variations in shear belts: Canadian Journal of Earth Sciences, v. 7, 786-813.

Ransome, F. L., 1903, Geology of the Globe copper district, Arizona: U.S. Geological Survey Professional Paper 12, 168 p.

Ransome, F. L., 1919, The copper deposits of Ray and Miami, Arizona: U.S. Geological Survey Professional Paper 115, 192 p.

Ransome, F. L., 1923, Description of the Ray quadrangle: U.S. Geological Survey Folio 217, 24 p.

Read, H. H., and Watson, Janet, 1975, Introduction to geology, Volume 2, Earth history, Part I, Early stages of earth history: New York, John Wiley and Sons, 221 p.

Schwerdtner, W. M., Stone, D., Osadetz, K., Morgan, J., and Stott, G. M., 1979, Granitoid complexes and the Archean tectonic record in the southern part of northwestern Ontario: Canadian Journal of Earth Sciences, v. 16, p. 1965-1977.

Shride, A. F., 1961, Some aspects of younger Precambrian geology in southern Arizona: Tucson, University of Arizona, Ph. D. dissertation, 234 p.

Shride, A. F., 1967, Younger Precambrian geology in southern Arizona: U.S. Geological Survey Professional Paper 566, 89 p.

Silver, L. T., 1954, Structure and petrology of the Johnny Lyon Hills area, Arizona: Pasadena, California Institute of Technology, unpublished Ph. D. dissertation, 407 p.

Silver, L. T., 1964, Mazatzal orogeny and tectonic episodicity [abs.]: Geological Society of America Special Paper 82, p. 185-186.

Silver, L. T., 1966, U-Pb isotope relations and their historical implications in Precambrian zircons from Bagdad, Arizona [abs.]: Geological Society of America Special Paper 101, p. 420.

Silver, L. T., 1967, Apparent age relations in the older Precambrian stratigraphy of Arizona [abs.], *in* Burwash, R. A., and Morton, R. D., eds., I.U.G.S. Committee Conference on Geochronology of Precambrian stratified rocks: Edmonton, University of Alberta Conference, p. 87.

Silver, L. T., 1968, Precambrian batholiths of Arizona [abs.]: Geological Society of America Special Paper 121, p. 558-559.

Silver, L. T., 1976, The Precambrian geochronology of central Arizona: Tucson, University of Arizona, oral presentation.

Silver, L. T., 1978, Precambrian formations and Precambrian history in Cochise County, southeastern Arizona, *in* Callender, J. F., Wilt, J. C., and Clemons, R. E., eds., Land of Cochise: Socorro, New Mexico Geological Society Guidebook, 29th Field Conference, p. 157-163.

Silver, L. T., Conway, C. M., and Ludwig, K. R., 1986, Implications of a precise chronology for early Proterozoic crustal evolution and caldera formation in the Tonto Basin-Mazatzal Mountains region, Arizona: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 413.

Silver, L. T., and Woodhead, J. A., 1983, Uranium and thorium endowment, distribution and mobilization in radioactive Precambrian granites II: Geological Society of America Abstracts with Programs, v. 15, no. 6, p. 688.

Steiger, R. H., and Jaeger, E., 1977, Subcommission on geochronology: Convention and use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359-362.

Stensrud, H. L., and More, Syver, 1980, Precambrian geology and massive sulfide environments of the west-central Hualapai Mountains, Mohave County, Arizona—a preliminary report: Arizona Geological Society Digest 12, p. 155-165.

Sutton, John, ed., 1976, A discussion on global tectonics in Proterozoic times: Philosophical Transactions of the Royal Society of London, Series A, v. 280, p. 397-663.

Swan, M. M., 1976, The Stockton Pass fault: an element of the Texas Lineament: Tucson, University of Arizona, unpublished M. S. thesis, 119 p.

Tchalenko, J. S., 1970, Similarities between shear zones of different magnitudes: Geological Society of America Bulletin, v. 81, p. 1625-1640.

Trevena, A. S., 1979, Studies in sandstone petrology: origin of the Precambrian Mazatzal Quartzite and provenance of detrital feldspar: Salt Lake City, University of Utah, unpublished Ph. D. dissertation, 390 p.

Trevena, A. S., 1981, Origin of the Precambrian Mazatzal Quartzite and related strata, central Arizona: Geological Society of America Abstracts with Programs, v. 13, no. 2, p. 111.

Van Hise, C. R., 1892, Correlation papers; Archean and Algonkian: U.S. Geological Survey Bulletin 86 (Arizona p. 326-332.)

Van Hise, C. R., and Leith, C. K., 1909, Pre-Cambrian geology of North America: U.S. Geological Survey Bulletin 360, p. 45 and 771-779.

Walcott, C. D., 1890, Study of line displacement in the Grand Canyon of the Colorado, in northern Arizona: Geological Society America Bulletin, v. 1, p. 49-64.

White, A. J. R., and Chappell, B. W., 1977, Ultrametamorphism and granitoid genesis: Tectonophysics, v. 43, p. 7-22.

Wilson, E. D., 1939, Pre-Cambrian Mazatzal Revolution in central Arizona: Geological Society of America Bulletin, v. 50, p. 1113-1164.

Wilson, E. D., 1962, A résumé of the geology of Arizona: Arizona Bureau Mines Bulletin 171, 140 p.

Winn, P. S., 1982, Structure and petrology of Precambrian rocks in the Black Canyon area, Yavapai County, Arizona: Salt Lake City, University of Utah, unpublished M. S. thesis, 101 p.

Wirth, K. R., 1980, The geology, stratigraphy and tectonic setting of the Mazatzal Quartzite in Chino Valley, Arizona: Beloit, University of Wisconsin, unpublished B. Sc. honors thesis, 35 p.

Revised manuscript accepted 1989.

*in* Jenney, J. P., and Reynolds, S. J., 1989, Geologic evolution of Arizona: Tucson, Arizona Geological Society Digest 17, p. 149-163.

# GEOCHEMISTRY AND TECTONIC POLARITY OF EARLY PROTEROZOIC (1700-1750-Ma) PLUTONIC ROCKS, NORTH-CENTRAL ARIZONA

by
Ed DeWitt

U.S. Geological Survey
Denver, Colorado 80225

## ABSTRACT

The Early Proterozoic terrane surrounding Prescott, Arizona, contains abundant 1700-1750-Ma pre-, syn-, and posttectonic granitic to tonalitic plutons that intrude 1720-1780-Ma metavolcanic rocks and minor metasedimentary rocks. Seventeen major plutonic bodies sampled during this study can be grouped into four distinct and genetically related suites defined by differences in major- and minor-element concentrations.

1. Suite one consists of pretectonic, equigranular, medium-grained biotite granodiorite and leucocratic granodiorite and granite plutons including the 1750 ± 10-Ma Brady Butte Granodiorite, the granodiorite of Minnehaha, the granodiorite of Big Bug Creek, the Crooks Canyon Granodiorite, the granodiorite of Lane Mountain, and the granite of Rich Hill. The plutons are moderately peraluminous, have very low magnetite concentrations and low to average Sr, and crop out in the central part of the area.
2. Suite two consists of pre- to syntectonic, equigranular, medium-grained hornblende-biotite tonalite and granodiorite plutons including the 1740 ± 15-Ma tonalite of Cherry and the 1750 ± 15-Ma Government Canyon Granodiorite, the granodiorite of Wilhoit, and the Prescott Granodiorite. The plutons are metaluminous, have high magnetite and Sr concentrations, and are located both northwest and southeast of suite 1.
3. Suite three consists of pre- to late-tectonic, equigranular to porphyritic, medium- to coarse-grained biotite-hornblende granodiorite plutons including the 1720-Ma quartz diorite of Bland, the Bumblebee Granodiorite, and the Badger Spring Granodiorite. The plutons are metaluminous, have low magnetite concentrations, low Rb, Zr, La, and Ce, and very low Sr, and are restricted to the southeastern part of the area.
4. Suite four consists of syn- to posttectonic, moderately to coarsely porphyritic, coarse-grained biotite granodiorite to granite plutons including the 1700 ± 5-Ma Crazy Basin Quartz Monzonite, the granite of Iron Springs, the granodiorite of Yarnell, and the granodiorite of Hozoni Ranch. All except Crazy Basin are metaluminous and have moderate to high magnetite concentrations and high Ba, Rb, Zr, La, and Ce. All except Crazy Basin are restricted to the northwestern part of the area.

At constant $SiO_2$ or $FeO_t$, plutons within any one suite have increasingly greater alkalinity and higher concentrations of incompatible minor elements to the northwest. Most modern oceanic and Andean arc granitoid rocks possess similar polarities with regard to the same elements, i.e., K, Rb, Zr, Y, La, Ce, U, and Th increase in concentration across strike of the arc and toward the back-arc region or continent. Although a discrete subduction or collision zone cannot be recognized southeast of the Prescott area, compositions of the 1700-1750-Ma plutons indicate that processes leading to the formation of the plutons were consistent with northwestward subduction of oceanic crust beneath the Prescott area from 1750 to 1700 Ma. Such a subduction zone and trench would have been at least 60 to 100 km to the southeast, in the vicinity of Globe or Superior, Arizona. Any evidence of such a trench has since been obliterated by later tectonic events, including emplacement of the 1400-Ma Ruin Granite.

## INTRODUCTION

Central Arizona contains the largest exposure of Proterozoic plutonic and metamorphic rocks south of the Canadian Shield. Although plutonic rocks are more voluminous here than metamorphic rocks, the plutons have been studied only cursorily. This paper presents major- and minor-element data for a variety of plutonic bodies in the region near Prescott, Arizona (fig. 1), and relates the evolution of those bodies to subduction processes that may have operated during the Early Proterozoic as originally suggested by DeWitt (1986) and Anderson (1986b).

## BACKGROUND AND TECTONIC SETTING

The plutonic rocks of this study intrude and deform a predominantly metavolcanic suite of rocks ranging from basalt to rhyolite, which was first recognized by Jaggar and Palache (1905) and later described in detail by Lindgren (1926), Anderson and Creasey (1958), Anderson and Blacet (1972b), Anderson and Nash (1972), and DeWitt (1979). Most recently, Anderson and Silver (1976) and Phillip Anderson (1978, 1986a, 1986b) have proposed that the volcanic rocks were formed in Proterozoic island arcs. Refer to Phillip Anderson (this volume) for some current

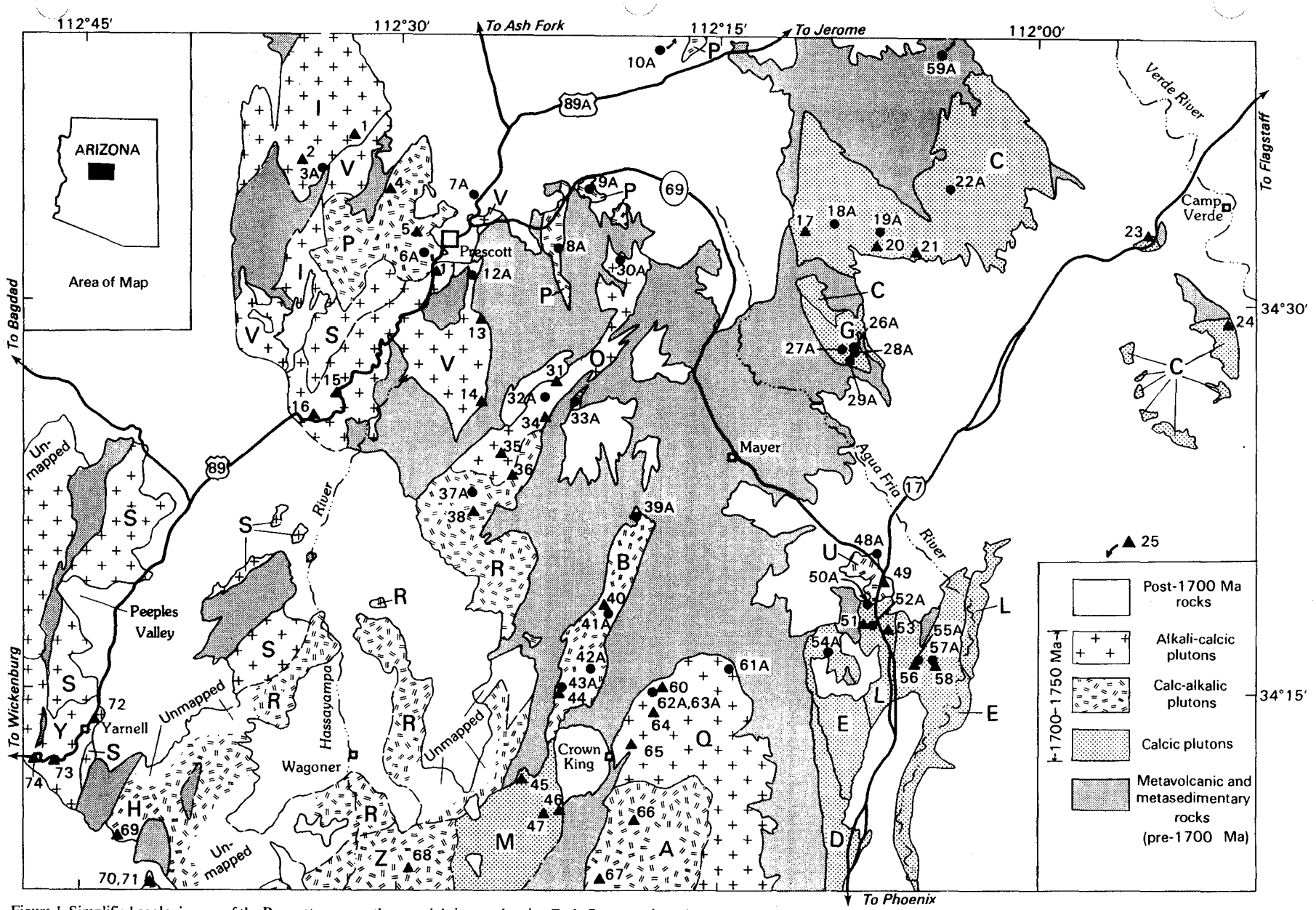



Figure 1. Simplified geologic map of the Prescott area, north-central Arizona, showing Early Proterozoic and post-Early Proterozoic rock units. Data from Krieger (1965, 1967), Anderson (1972), Anderson and Creasey (1958, 1967), Anderson and Blacet (1972a, 1972b, 1972c), DeWitt (1976, 1979), Jerome (1956), 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.

ideas concerning evolution of the metavolcanic terrane. Metasedimentary rocks are a minor part of the preplutonic bedrock in the northern and central parts of the region (fig. 1), but are approximately 25 percent in the southern part. All the preplutonic rocks have been metamorphosed to greenschist or higher metamorphic grade, possess a tectonic foliation that trends northeast in the western two-thirds of figure 1 and north in the eastern one-third, and have been mildly to isoclinally folded throughout.

Plutonic rocks in the Prescott area range in chemical and modal composition from tonalite to granite and in texture and structure from highly foliated, highly deformed to completely unfoliated and undeformed bodies. Some of the sampled plutons have been isotopically dated (Anderson and others, 1971; Bowring and others, 1986), but many have not. All of the plutons are believed to be 1700-1750 Ma because they have structural and chemical similarities to rocks of that age range dated elsewhere in Arizona (Silver, 1968; Conway, 1976; Ludwig, 1973; Silver and others, 1986; Bryant and Wooden, 1986). Numerous gabbroic plutons genetically associated with the mafic metavolcanic rocks are not discussed in this geochemical summary, but their approximate location is shown for reference on some minor-element plots. Gabbroic rocks are included with the metavolcanic and metasedimentary rocks on figure 1.

The formally named plutonic bodies discussed in this paper have been mapped and some of their major-element chemistry published by Anderson and Creasey (1958, 1967), Krieger (1965), Blacet (1966, 1968, 1985), Anderson (1972), and Anderson and Blacet (1972a, 1972b, 1972c). The bodies that are given informal names in this paper have been mapped in reconnaissance by the author. Diagnostic features, including names, isotopic age determinations, modal averages, mineralogy, magnetic susceptibility, and classifications according to major- and minor-element chemistry, are listed in table 1.

## ANALYTICAL PROCEDURES

Samples for major- and minor-element analyses were collected from blasted roadcuts or fresh outcrops. Rocks for major-element analyses were ground in ceramic pulverizers to less than 200 mesh. Major elements were determined by X-ray fluorescence of fused disks. For minor-element determinations the rocks were ground in a jaw crusher, split, and pulverized to less than 200 mesh in a tungsten carbide ball mill. Approximately 5-6 grams of powder were pressed into pellets and analyzed by X-ray fluorescence using a Kevex energy-dispersive detector. Rb, Sr, Y, Nb, Zr, and total iron as FeO were analyzed with a $^{109}$Cd source, and Ba, La, and Ce were analyzed with an $^{241}$Am source. Detection limits for various elements are listed in table 2; the accuracy of the measurements is approximately $\pm$ 2 percent.

Samples for magnetic susceptibility measurements were those used for major- and minor-element geochemistry. A JH-8 susceptibility meter, manufactured by Geoinstruments Ky, Helsinki, Finland, was used for the measurements. The JH-8 meter has a sensitivity of $5 \times 10^{-5}$ SI and can measure magnetic susceptibilities in the range $5 \times 10^{-5}$ to $1 \times 10^{-1}$ SI from natural specimens without the specimen having been drilled or cored. For purposes of this study, magnetite was assumed to be the only magnetic substance in the rocks. The percentage of magnetite was calculated from the measured magnetic susceptibility using a logarithmic Balsley-Buddington chart.

## MAJOR- AND MINOR-ELEMENT GEOCHEMISTRY

The various plutonic bodies will be summarized in chronological order, from presumed oldest to youngest, and within each of four suites that have geochemical affinities. Because many of the plutons have not been dated, errors may exist in this sequential listing; I hope that the summary will indicate areas for future research, both geochemical and geochronologic.

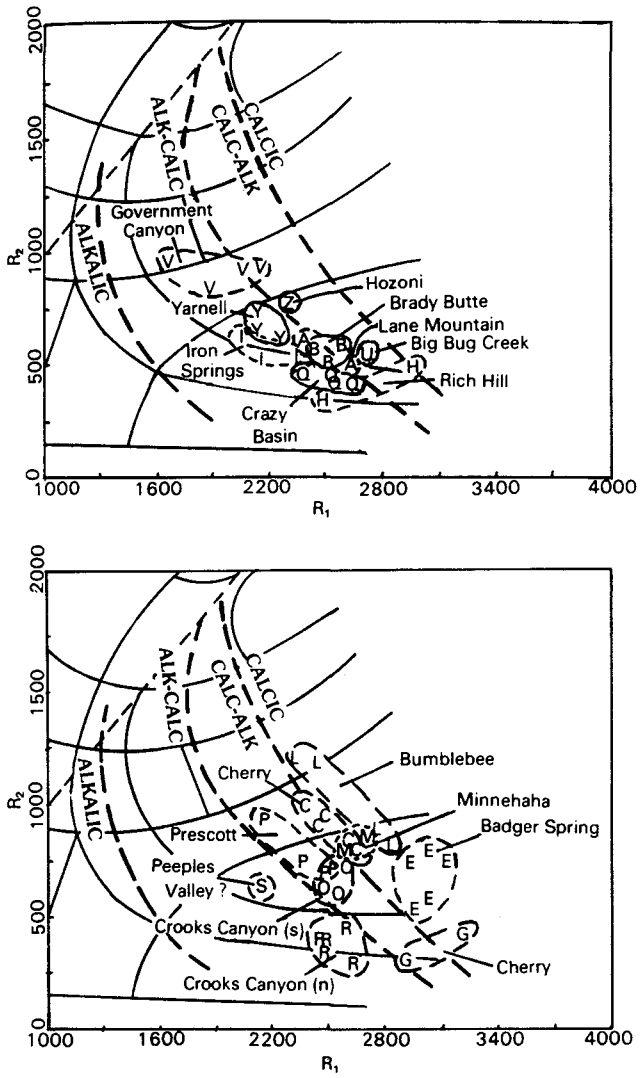
Rock names used in this paper are based on the chemical classification of De la Roche and others (1980). Modifiers include those based on $Na_2O + K_2O$ concentration, i.e., calcic, calc-alkalic, and alkali-calcic (Peacock, 1931; Keith, 1978), degree of iron or magnesium enrichment (Miyashiro, 1974), $K_2O$ concentration (Peccerillo and Taylor, 1976), and molar alumina saturation, i.e., metaluminous, mildly peraluminous, or strongly peraluminous (Shand, 1927; Keith, 1986). All dates have been recalculated using the decay constants recommended by Steiger and Jaeger (1977).

### Suite 1: Pre-tectonic biotite granodiorite and granite plutons (moderately peraluminous, low to average Sr, very low magnetite).

*Brady Butte Granodiorite (Blacet, 1966).* This 1750 $\pm$ 10-Ma equigranular, calc-alkalic biotite granodiorite (figs. 2 and 3), the oldest dated pluton in north-central Arizona (Anderson and others, 1971), discordantly intrudes the metavolcanic terrane and is unconformably overlain by the metamorphosed and deformed Texas Gulch Formation (Blacet, 1968; O'Hara and others, 1978; Karlstrom and O'Hara, 1984). The pluton is foliated to gneissic throughout and is cut by numerous mylonitic zones that parallel the northeast-trending, high-angle foliation found in the metavolcanic terrane. The granodiorite exhibits marked iron and magnesium enrichment (fig. 4), an unusual feature for any 1700-1750-Ma pluton in the area. Brady Butte, somewhat surprisingly, is moderately to strongly peraluminous. Deformation of the pluton and growth of minor muscovite during regional metamorphism may account for the peraluminous nature of the body, as minor loss of alkali elements may have taken place during deformation. Brady Butte has the lowest percentage of magnetite (0.2 percent) of any of the granodioritic plutons studied. The granodiorite stands out as a 200-gamma magnetic low on the aeromagnetic

Table 1. Characteristics of 1700-1750-Ma plutonic rocks, north-central Arizona. [References for rock units: 1, Krieger (1965); 2, Blacet (1966, 1968); 3, Anderson and Blacet (1972b, 1972c); 4, Anderson and Creasey (1958); 5, Jerome (1956); 6, Vrba (1980); 7, Anderson and others (1971); 8, Karlstrom and Conway (1986); 9, Bowering and others (1986); 10, this study. Within groups, rock units listed in order of increasing alkalinity. Mode based on I.U.G.S. classification—gd, granodiorite; ton, tonalite; mzdi, monzodiorite; mzgr, monzogranite. Mineralogy—plag, plagioclase; qtz, quartz; mic, microcline; or, orthoclase; per, perthite; hb, hornblende; bt, biotite; ep, epidote; mt, magnetite; zr, zircon; ap, apatite; all, allanite; sph, sphene; ms, muscovite; kf, potassium feldspar. Rock names based on classification of De la Roche and others (1980); gd, granodiorite; ton, tonalite; gr, granite—see fig. 2 for explanation. Alkalinity based on both figs. 2 and 3—first entry is classification of fig. 2; entry in parentheses is classification of fig. 3—C, calcic; CA, calc-alkalic; AC, alkali-calcic. $K_2O$ index based on classification of fig. 4—L, low; M, medium; H, high. Fe, Mg index based on classification of fig. 5—Mg, magnesium-rich; Fe, iron-rich; ~Mg, slightly magnesium-rich; ~Fe, slightly iron-rich; >Mg, strongly; magnesium-rich; >Fe, strongly iron-rich; ≥Fe, slightly to strongly iron-rich; Mg=Fe, neither iron- nor magnesium-rich. Al index based on molar ratio of Al/Ca+Na+K—M, metaluminous, <1; <1; ~P moderately peraluminous, >1, but <1.1; >P, strongly peraluminous, >1.1. Suites are those discussed in the text. --, characteristic not determined. *, unusual characteristic that is discussed in text]

| Rock Unit (reference) | Age (Ma) | Mode (IUGS) | Mineralogy | Magnetite (%) | Rock name | Alkalinity | $K_2O$ index | Fe, Mg index | Al index | Suite |
|---|---|---|---|---|---|---|---|---|---|---|
| Calcic Rocks | | | | | | | | | | |
| Badger Spring Granodiorite (3) | <1720 | -- | Plag-qtz-bt-kf-sph-zr-ap | 1.5 | Gd | C (C) | L-M | ~Mg | M | 3 |
| Bumblebee Granodiorite (3) | ~1720 | -- | Plag-hb-qtz-kf-sph-ap-zr-mt | 1.6 | Gd-ton | C (C) | M | Fe*-Mg | M | 3 |
| Granodiorite of Minnehaha (10) | -- | -- | -- | 0.9 | Gd | C (CA) | M | Mg | M | 1 |
| Tonalite of Cherry (4,7) | 1740 ± 15 | Ton-gd | Plag-or,mic-qtz-hb-bt-mt-ap-sph | 7.0 | Ton | CA-C (CA) | M | Mg | M | 2 |
| Granophyre of Cherry (4) | ~1740 | -- | -- | -- | Gr | CA-C (C) | M-L | Fe | >P* | 2 |
| Quartz Diorite of Bland (5,9) | 1720 | -- | Plag-hb-bt-qtz | 0.2 | -- | -- | -- | -- | -- | 3 |
| Calc-Alkalic Rocks | | | | | | | | | | |
| Crooks Canyon Granodiorite [South] (10) | <1750 | -- | -- | 1.5 | Gd | CA (CA) | M | Mg | ~P | 1 |
| Prescott Granodiorite (1) | <1750 | Gd | Plag-qtz-mic,or-bt-ep-sph-mt-zr-ap | 4.2 | Gd | CA (CA-AC) | M | >Mg | ~P* | 2 |
| Granodiorite of Big Bug Creek (10) | -- | -- | -- | 0.2 | Gd | CA (C*) | L* | ~Mg | >P* | 1 |
| Granite of Rich Hill (10) | -- | -- | -- | 0.8 | Gr | CA-AC (CA-AC) | M-H | Mg=Fe | ~P | 1 |
| Brady Butte Granodiorite (2,7) | 1750 ± 10 | Gd | Plag-qtz-mic-bt-ep-sph-mt-ms | 0.2 | Gd | CA-AC (CA) | M-H | >Mg->Fe* | ~P->P | 1 |
| Granodiorite of Lane Mountain (10) | -- | -- | -- | 0.7 | Gd | CA-AC (CA) | M | ~Mg | M | 1 |
| Granodiorite of Hozoni Ranch (10) | -- | -- | -- | 2.8 | Gd | CA (CA-AC) | H | ~Mg | M | 4 |
| Alkali-Calcic Rocks | | | | | | | | | | |
| Government Canyon Granodiorite (1) | 1750 ± 15 | Gd-mzdi | Plag-qtz-or-hb-bt-ep-sph | 4.5 | Ton | AC (AC) | M*-H | >Mg | M | 2 |
| Granodiorite of Wilhoit (10) | ~1750 | -- | -- | 3.5 | Gd | AC (AC) | -- | -- | -- | 2 |
| Granodiorite of Yarnell (10) | -- | -- | -- | 8.0 | Gd | AC (AC) | H | ~Fe | M | 4 |
| Granite of Iron Springs (10) | -- | -- | -- | 5.3 | Gr-gd | AC (AC) | H | ~Mg | M | 4 |
| Crazy Basin Quartz Monzonite (2,6,8) | 1700 ± 5 | -- | Mic-plag-qtz-bt-ms-sph-mt-zr | 0.5 | Gr | AC (AC) | H | ≥Fe | ~P | 4 |
| Crooks Canyon Granodiorite [North] (3,10) | <1750 | Gd-mzgr | Mic,per-plag-bt-qtz-zr-all | 1.5 | Gr | AC (AC) | H | ≥Fe | ~P | 1 |



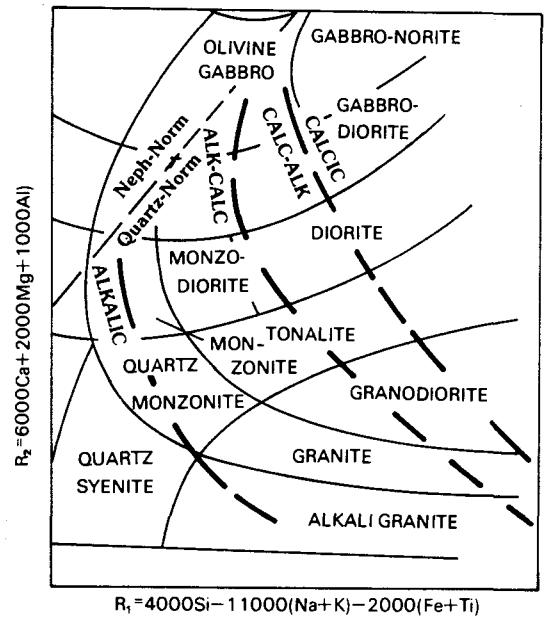




Figure 2. $R_1$-$R_2$ classification (De la Roche and others, 1980) for 1700-1750-Ma plutonic rocks, north-central Arizona. Data from Anderson (1972), Anderson and Blacet (1972b), Anderson and Creasey (1958), Blacet (1968), Krieger, (1965), Lee (1984), Vrba (1980), and this study. A, granodiorite of Lane Mountain; B, Brady Butte Granodiorite; C, tonalite of Cherry; 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. Names of rock types shown in inset. Calcic, calc-alkalic, alkali-calcic, and alkalic field boundaries from DeWitt (unpub. data, 1986) and from the boundaries on figure 3.

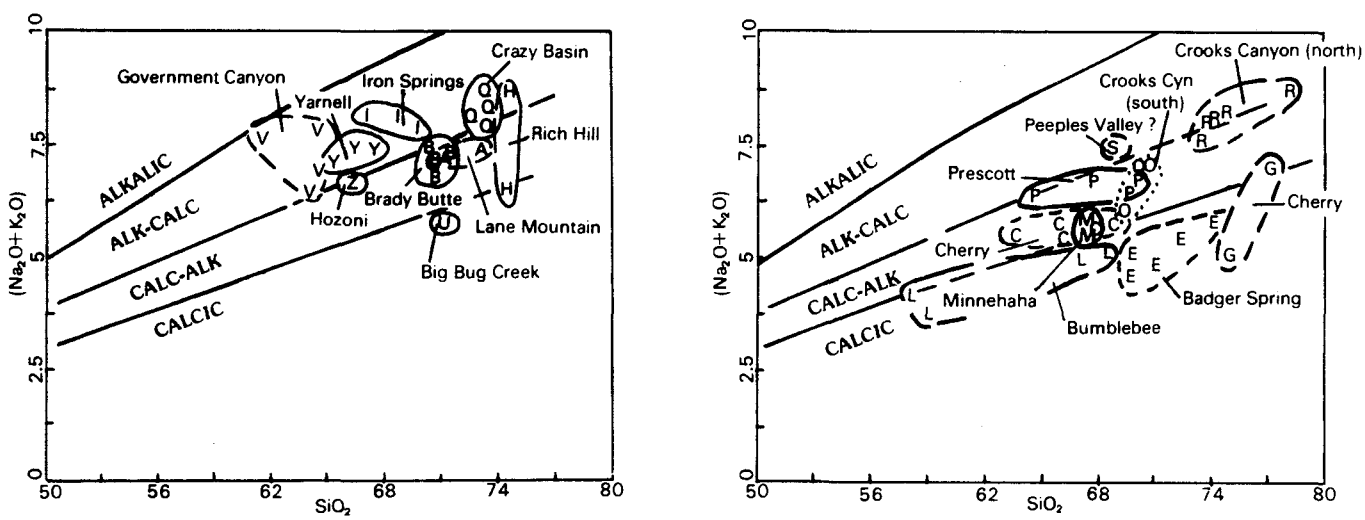



Figure 3. $Na_2O + K_2O$ versus $SiO_2$ diagrams for 1700-1750-Ma plutonic rocks, north-central Arizona. Calcic, calc-alkalic, alkali-calcic, and alkalic field boundaries from Anderson (1983) and DeWitt (unpub. data, 1986). Plotting symbols as in figure 2.

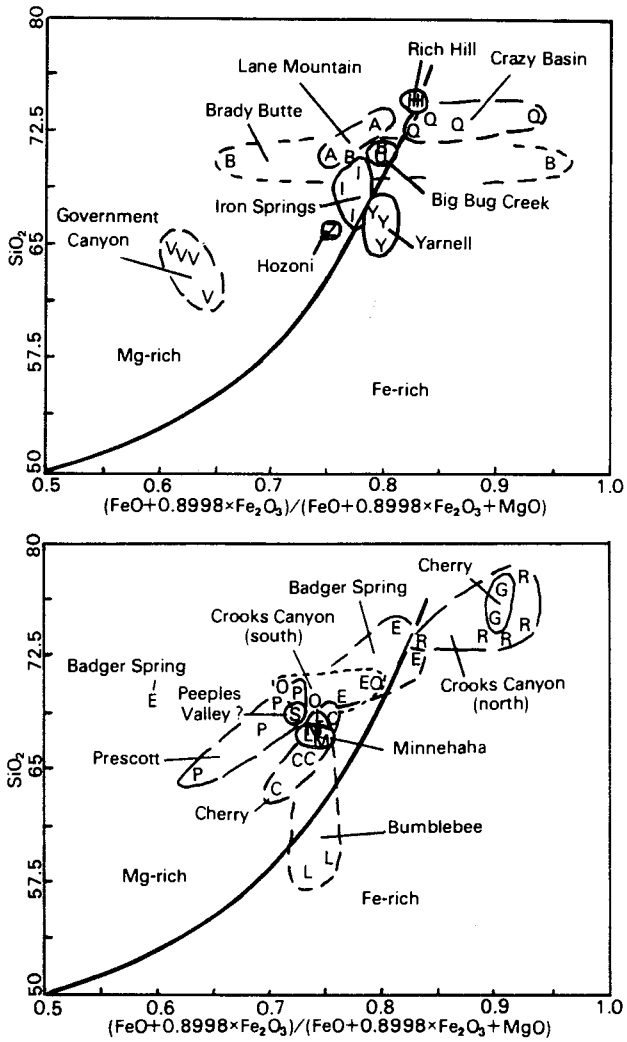



Figure 4. $SiO_2$ versus ($FeO + 0.90Fe_2O_3$)/($FeO + 0.90Fe_2O_3 + MgO$) diagram for plutonic rocks, north-central Arizona. Mg-rich and Fe-rich field boundary from Miyashiro (1974) as modified by Anderson (1983). Fields originally called calc-alkaline (Mg-rich) and tholeiitic (Fe-rich) by Miyashiro (1974). Plotting symbols as in figure 2.

map of the Bradshaw Mountains (U.S. Geological Survey, 1972) and on the residual intensity anomaly map of the Prescott 1° by 2° quadrangle (Aero Services, 1983). Brady Butte has average Ba, Rb, Sr, Zr, Nb, La, and Ce concentrations relative to the other studied plutons but could be considered a trondhjemite (Barker, 1979) on the basis of its relatively low Rb concentration.

*Granodiorite of Minnehaha (new informal name).* This equigranular, calcic biotite-hornblende granodiorite is the southwestern extension of the Brady Butte Granodiorite but is given an informal new name because of its more calcic nature and more mafic composition. The pluton is named for exposures along Minnehaha Creek, 3 miles southwest of Crown King. The granodiorite is foliated to gneissic on its western margin but is massive to slightly foliated on its eastern margin. Relative ages of this granodiorite and Brady Butte are unknown. Magnetite concentration of the pluton is low (0.9 percent), especially for a relatively hornblende-rich granodiorite. The aeromagnetic low defined by the Brady Butte Granodiorite is interrupted by the Cretaceous stock at Crown King (DeWitt, 1976), but a low of lesser magnitude continues southwest along this granodiorite (U.S. Geological Survey, 1972). The pluton exhibits moderate magnesium enrichment (fig. 4) similar to most of the 1700-1750-Ma plutons. The granodiorite has identical minor-element chemistry to Brady Butte except that it contains slightly less Sr. The Brady Butte Granodiorite and this pluton probably were derived from a very similar parent magma.

The granodiorite of Minnehaha could belong to suite 2 and be related to the tonalite of Cherry. However, the granodiorite is very depleted in Sr and magnetite for a suite 2 pluton. Additional study may be necessary to determine in which suite the granodiorite belongs.

*Granodiorite of Big Bug Creek (new informal name).* The equigranular, calc-alkalic biotite granodiorite of Big Bug Creek is megascopically identical to the Brady Butte Granodiorite. Previously, much of the granodiorite was described by Anderson and Blacet (1972c) as a diorite porphyry. The pluton is named for exposures along Big Bug Creek, about 9 miles southeast of Mayer. Size and shape of the body are poorly known at present. The granodiorite is highly foliated, contains very little magnetite, has anomalously low total alkalis (fig. 3) and $K_2O$ (fig. 5), and is strongly peraluminous. Quite likely the granodiorite has been depleted in alkali elements during deformation and metamorphism. The one analysis of the pluton indicates very low Rb and low Ba compared to either Brady Butte or Minnehaha. The granodiorite may belong to suite 3 but would be unusual for that group because of its peraluminous nature.

*Crooks Canyon Granodiorite (Anderson and Blacet, 1972a).* The southern part of this granodiorite is a medium-grained, equigranular, leucocratic, calc-alkalic biotite granodiorite and is one of the largest plutonic bodies in the Prescott area. The granodiorite extends southwest from the Bradshaw Mountains past Wagoner to the southwest. North of Wagoner the granodiorite intrudes the granodiorite of Wilhoit. Some of the body southwest of the Hassayampa River is unmapped. Northwest and southwest of Wagoner the -400 gamma-contour on the magnetic anomaly map of the Prescott 1° by 2° quadrangle (Aero Services, 1983) appears to approximately delineate the boundaries of the pluton. The equigranular part of the body is mildly foliated in most exposures, but its late felsic differentiates are undeformed. These felsic rocks cut the foliated granodiorite of Minnehaha southeast of Wagoner. Although more leucocratic than the granodiorite of Minnehaha or the Brady Butte Granodiorite, the southern part of this granodiorite is slightly more magnetic than either of them (table 2). The southern part of this body is low in Rb, Y, La, and Ce (fig. 6; tables 2 and 3) compared to other plutons in the area. The minor-element concentrations of the southern part of Crooks Canyon strongly resemble those of the granodiorite of Lane Mountain described below.

The northern part of Crooks Canyon, a medium- to fine-grained, leucocratic, alkali-calcic biotite granite, differs from the southern part by having higher $SiO_2$, total alkalis, and $K_2O$ and by being moderately to strongly iron rich. The granite is variably foliated to strongly mylonitic, indicating a pretectonic age of the body. Most of what Anderson and Blacet (1972a) described as Crooks Canyon has the same texture as this fine-grained northern part of the body. Magnetite concentration in the northern part is the same as the southern part. Minor-element concentrations, particularly higher than average Ba, Y, La, and Ce, and lower than average Sr, indicate that the northern part of the body is

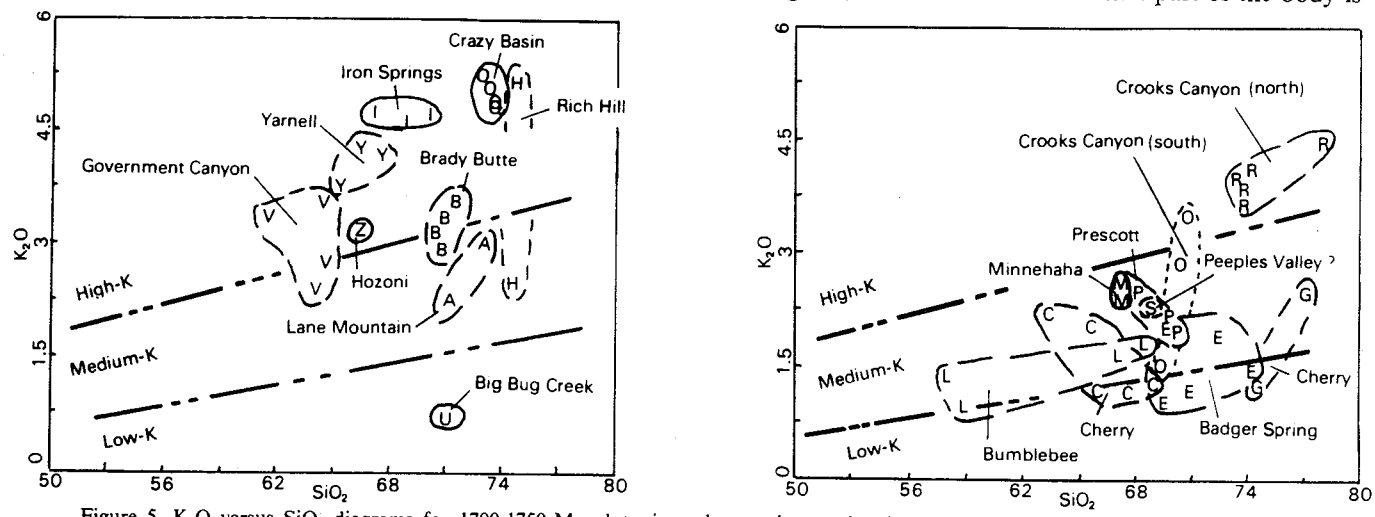



Figure 5. $K_2O$ versus $SiO_2$ diagrams for 1700-1750-Ma plutonic rocks, north-central Arizona. Low-K, medium-K, and high-K field boundaries from Peccerillo and Taylor (1976). Plotting symbols as in figure 2.

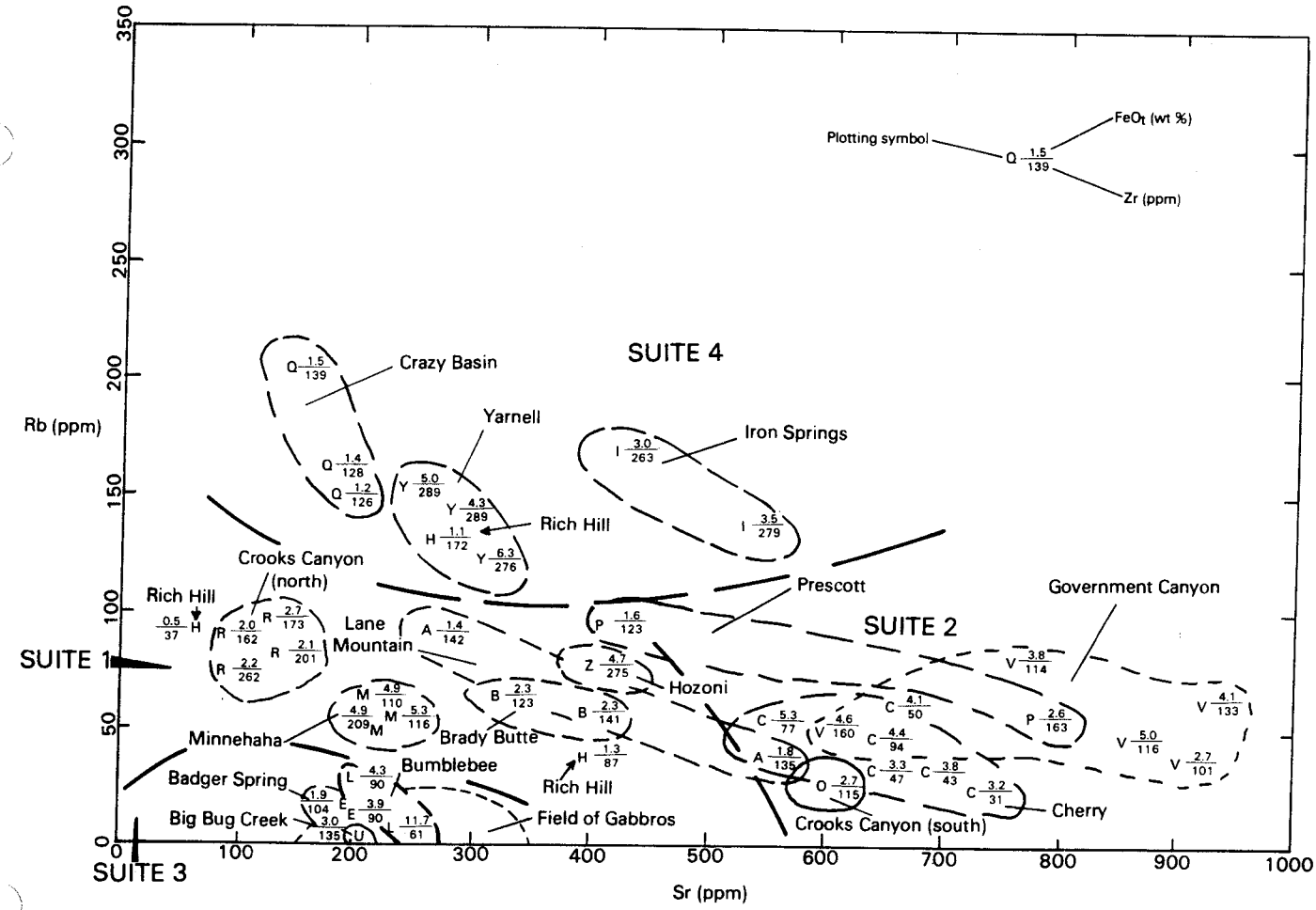



Figure 6. Rb versus Sr diagram for 1700-1750-Ma plutonic rocks, north-central Arizona. Fields of suites 1-4 (discussed in text) are shown. Plotting symbols as in figure 2.

much more evolved than the southern part. A 200-gamma, northeast-trending magnetic low (U.S. Geological Survey, 1972) delineates the body. The high La, Ce, and Y concentrations in the body probably account for abundant allanite in the granite, a mineral that strongly partitions Ce and light rare-earth elements (Arth and Hanson, 1975; Dodge and others, 1982). Except for the much higher Zr concentration in the northern part of the pluton, the two phases could be related to one another by simple fractional crystallization, which would also explain the strong iron enrichment trend for the northern part of the body.

*Granodiorite of Lane Mountain (new informal name).* This equigranular to slightly porphyritic calc-alkalic to alkali-calcic biotite granodiorite was mistakenly assumed to be part of the Crazy Basin Quartz Monzonite by DeWitt (1976, 1979) but is now known to be a foliated pluton older

Table 2. Major- and minor-element chemistry of 1700-1750-Ma plutonic rocks, north-central Arizona. [Number, i.e. 2, refers to sample location on fig. 1; letter in parentheses (M) is plotting symbol on figs. 2-8; major-element oxides (in weight percent) determined by X-ray fluorescence by J.E. Taggart, A.J. Bartel, and K.C. Stewart; $Fe_tO_3$, total iron as $Fe_2O_3$; LOI, loss on ignite minor elements (in parts per million) determined by X-ray fluorescence by Ed DeWitt and Ross Yeoman on Kevex detector; [6] detection limit for element listed; --, below detection limit for element listed]

| | Rock Unit, Field Sample Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Granite of Iron Springs | | Government Canyon Granodiorite | | | Tonalite of Cherry | | Crooks Canyon Granodiorite (north) | | |
| | 12-1-84-4 | 11-30-84-9 | 11-30-84-6 | 11-30-84-4 | 11-26-84-2 | 11-27-84-1 | 11-27-84-3 | 11-30-84-2 | 12-1-84-2 | 12-1-84-1 |
| | 1 (I) | 2 (I) | 11 (V) | 14 (V) | 15 (V) | 17 (C) | 21 (C) | 31 (R) | 35 (R) | 36 (R) |
| $SiO_2$ | 70.0 | 67.0 | 64.5 | 64.5 | 64.0 | 63.3 | 67.5 | 74.0 | 73.3 | 73.6 |
| $Al_2O_3$ | 13.9 | 15.0 | 15.2 | 15.2 | 15.1 | 15.8 | 16.2 | 13.0 | 13.3 | 13.2 |
| $Fe_tO_3$ | 3.78 | 4.06 | 4.67 | 4.32 | 5.07 | 5.74 | 3.69 | 2.41 | 2.50 | 2.63 |
| MgO | 0.98 | 1.05 | 2.62 | 2.47 | 2.67 | 2.15 | 1.12 | 0.18 | 0.45 | 0.24 |
| CaO | 2.02 | 2.53 | 4.44 | 3.73 | 4.54 | 5.23 | 4.38 | 0.97 | 1.55 | 1.15 |
| $Na_2O$ | 3.01 | 3.30 | 4.12 | 4.09 | 3.96 | 3.29 | 4.21 | 4.02 | 3.59 | 4.10 |
| $K_2O$ | 4.77 | 4.72 | 2.73 | 3.61 | 2.36 | 2.20 | 1.23 | 4.06 | 3.98 | 3.86 |
| $TiO_2$ | 0.61 | 0.72 | 0.51 | 0.45 | 0.71 | 0.45 | 0.31 | 0.15 | 0.21 | 0.18 |
| $P_2O_5$ | 0.22 | 0.25 | 0.32 | 0.23 | 0.28 | 0.18 | 0.15 | 0.05 | 0.06 | <0.05 |
| MnO | 0.08 | 0.09 | 0.06 | 0.05 | 0.06 | 0.09 | 0.06 | 0.06 | 0.06 | 0.06 |
| LOI | 0.52 | 0.60 | 0.60 | 0.79 | 0.98 | 1.14 | 1.71 | 0.61 | 0.53 | 0.35 |
| Total | 99.89 | 99.32 | 99.77 | 99.44 | 99.73 | 99.57 | 100.56 | 99.51 | 99.53 | ~99.39 |
| Ba [6] | 1557 | 1782 | 802 | 1085 | 831 | 710 | 598 | 1315 | 1166 | 1438 |
| Rb [6] | 168 | 134 | 60 | 80 | 46 | 48 | 24 | 84 | 96 | 73 |
| Sr [6] | 415 | 524 | 924 | 761 | 598 | 544 | 725 | 84 | 124 | 93 |
| Y [5] | 31 | 33 | 13 | 6 | 12 | 10 | -- | 49 | 36 | 51 |
| Zr [4] | 263 | 279 | 133 | 119 | 160 | 77 | 31 | 262 | 173 | 262 |
| Nb [3] | 25 | 29 | 16 | 15 | 22 | 12 | 12 | 23 | 19 | 24 |
| La [6] | 96 | 92 | 39 | 49 | 51 | 27 | 23 | 93 | 54 | 80 |
| Ce [7] | 196 | 162 | 91 | 91 | 100 | 38 | 30 | 169 | 96 | 144 |

Table 2. (cont.)

| | Rock Unit, Field Sample Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Crooks Canyon Granodiorite (south) | Granodiorite of Minnehaha | | Bumblebee Granodiorite | | Badger Spring Gd | Crazy Basin Quartz Monzonite | Granodiorite of Lane Mountain | | Granodiorite of Hozoni Ranch |
| | 12-1-84-3 | 11-29-84-4 | 11-28-84-11 | 11-27-84-12 | 11-27-84-7 | 11-27-84-11 | 11-28-84-1 | 11-28-84-5 | 11-28-84-9 | 11-29-84-5 |
| | 38 (O) | 45 (M) | 47 (M) | 51 (L) | 53 (L) | 56 (E) | 60 (O) | 66 (A) | 67 (A) | 68 (Z) |
| $SiO_2$ | 69.1 | 67.2 | 67.1 | 58.9 | 68.5 | 70.8 | 72.8 | 73.0 | 70.8 | 66.2 |
| $Al_2O_3$ | 16.0 | 14.8 | 15.0 | 14.5 | 14.0 | 14.0 | 14.2 | 14.8 | 15.3 | 14.7 |
| $Fe_tO_3$ | 3.10 | 5.43 | 4.73 | 10.2 | 4.80 | 4.21 | 1.78 | 1.80 | 2.18 | 5.41 |
| MgO | 1.00 | 1.73 | 1.44 | 3.00 | 1.49 | 0.98 | 0.34 | 0.42 | 0.65 | 1.58 |
| CaO | 3.53 | 4.38 | 4.11 | 6.90 | 4.20 | 4.02 | 1.33 | 1.76 | 2.39 | 3.76 |
| $Na_2O$ | 4.46 | 3.02 | 3.18 | 2.68 | 3.23 | 3.39 | 2.92 | 4.15 | 4.91 | 3.39 |
| $K_2O$ | 1.46 | 2.38 | 2.59 | 0.98 | 1.85 | 1.16 | 5.25 | 3.07 | 2.15 | 3.20 |
| LOI | 0.92 | 0.45 | 1.00 | 1.80 | 1.18 | 1.19 | 0.54 | 0.45 | 0.88 | 0.39 |
| $TiO_2$ | 0.29 | 0.43 | 0.36 | 0.90 | 0.41 | 0.32 | 0.15 | 0.22 | 0.29 | 0.72 |
| $P_2O_5$ | 0.12 | 0.14 | 0.64 | 0.33 | 0.13 | 0.10 | 0.08 | 0.07 | 0.10 | 0.28 |
| MnO | 0.06 | 0.09 | 0.08 | 0.18 | 0.08 | 0.08 | 0.04 | 0.02 | <0.02 | 0.09 |
| Total | 100.04 | 100.05 | 100.23 | 100.44 | 99.87 | 100.25 | 99.43 | 99.76 | ~99.66 | 99.72 |
| Ba | 723 | 779 | 759 | 391 | 686 | 533 | 917 | 829 | 547 | 1438 |
| Rb | 34 | 49 | 49 | 7 | 24 | 9 | 202 | 89 | 45 | 73 |
| Sr | 598 | 231 | 209 | 253 | 207 | 202 | 139 | 261 | 543 | 393 |
| Y | -- | 19 | 16 | 20 | 13 | 11 | 9 | -- | -- | 27 |
| Zr | 115 | 116 | 109 | 61 | 90 | 90 | 139 | 142 | 135 | 275 |
| Nb | 17 | 14 | 16 | 14 | 13 | 11 | 24 | 15 | 12 | 23 |
| La | 33 | 42 | 28 | 21 | 25 | 25 | 62 | 29 | 29 | 81 |
| Ce | 63 | 68 | 56 | 36 | 45 | 43 | 107 | 59 | 56 | 139 |

Table 2. (cont.)

| | Rock Unit, Sample Number | | | | |
|---|---|---|---|---|---|
| | Granite of Rich Hill | | Granodiorite of Yarnell | | |
| | 11-25-84-2 | 11-25-84-3A | 11-26-84-1 | 11-24-84-2 | 11-24-84-1 |
| | 69 (H) | 70 (H) | 72 (Y) | 73 (Y) | 74 (Y) |
| $SiO_2$ | 74.5 | 74.5 | 67.4 | 66.3 | 65.1 |
| $Al_2O_3$ | 13.1 | 13.8 | 14.5 | 14.1 | 14.3 |
| $Fe_tO_3$ | 1.50 | 1.64 | 4.98 | 5.45 | 6.65 |
| MgO | 0.28 | 0.31 | 1.17 | 1.22 | 1.52 |
| CaO | 0.66 | 1.85 | 2.57 | 2.84 | 3.43 |
| $Na_2O$ | 3.43 | 3.85 | 3.08 | 3.10 | 3.14 |
| $K_2O$ | 5.12 | 2.47 | 4.18 | 4.33 | 3.78 |
| LOI | 0.48 | 0.86 | 0.55 | 0.76 | 0.65 |
| $TiO_2$ | 0.19 | 0.12 | 0.80 | 0.79 | 1.02 |
| $P_2O_5$ | 0.05 | 0.02 | 0.27 | 0.34 | 0.39 |
| MnO | 0.04 | 0.06 | 0.12 | 0.11 | 0.13 |
| Total | 99.36 | 99.49 | 99.62 | 99.34 | 100.11 |
| Ba | 1167 | 1257 | 1129 | 1084 | 1034 |
| Rb | 141 | 39 | 143 | 145 | 117 |
| Sr | 276 | 394 | 276 | 248 | 296 |
| Y | 14 | 9 | 56 | 35 | 53 |
| Zr | 172 | 87 | 289 | 289 | 276 |
| Nb | 34 | 17 | 31 | 28 | 30 |
| La | 94 | 34 | 71 | 80 | 69 |
| Ce | 148 | 49 | 157 | 166 | 142 |

Table 3. Minor-element concentrations of 1700-1750-Ma plutonic rocks, north-central Arizona. [Sample numbers as in fig. 1; [0.02], detection limits for elements listed; --, element not detected; analyzed by X-ray fluorescence on Kevex detector by Ed DeWitt and Ross Yeoman; plotting symbols are those in figs. 2-8]

| Rock Unit | Plotting symbol | Sample No. | FeO (%) [0.02] | Ba (ppm) [6] | Rb (ppm) [6] | Sr (ppm) [6] | Y (ppm) [5] | Zr (ppm) [4] | Nb (ppm) [3] | La (ppm) [6] | Ce (ppm) [7] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Prescott Granodiorite | P | 4 | 2.6 | 1320 | 53 | 785 | 10 | 163 | 17 | 49 | 80 |
| Prescott Granodiorite | P | 5 | 1.6 | 1107 | 95 | 417 | 6 | 123 | 16 | 40 | 67 |
| Government Cyn. Gd. | V | 13 | 5.0 | 869 | 43 | 846 | 11 | 116 | 14 | 52 | 99 |
| Government Cyn. Gd. | V | 16 | 2.7 | 971 | 37 | 893 | 8 | 101 | 14 | 48 | 74 |
| Tonalite of Cherry | C | 20 | 3.8 | 630 | 31 | 676 | 6 | 43 | 6 | 22 | 32 |
| Tonalite of Cherry | C | 23 | 3.3 | 540 | 29 | 649 | 5 | 47 | 9 | 21 | 29 |
| Tonalite of Cherry | C | 24 | 4.1 | 661 | 56 | 651 | -- | 50 | 9 | 24 | 33 |
| Tonalite of Cherry | C | 25 | 4.4 | 545 | 50 | 637 | 9 | 94 | 15 | 30 | 66 |
| Crooks Cyn. Granodiorite | R | 34 | 2.1 | 1087 | 77 | 134 | 36 | 201 | 24 | 75 | 151 |
| Brady Butte Granodiorite | B | 40 | 2.3 | 1289 | 52 | 399 | 11 | 141 | 20 | 52 | 80 |
| Brady Butte Granodiorite | B | 44 | 2.3 | 1041 | 61 | 316 | 21 | 123 | 16 | 49 | 84 |
| Granodiorite of Minnehaha | M | 46 | 4.9 | 1024 | 49 | 214 | 19 | 110 | 16 | 30 | 54 |
| Gd. of Big Bug Creek | U | 49 | 3.0 | 385 | 4 | 201 | 42 | 135 | 13 | 29 | 53 |
| Badger Spring Gd. | E | 58 | 1.9 | 799 | 13 | 185 | 18 | 104 | 18 | 28 | 46 |
| Crazy Basin Qtz. Monz. | Q | 64 | 1.4 | 879 | 157 | 174 | 11 | 128 | 20 | 75 | 135 |
| Crazy Basin Qtz. Monz. | Q | 65 | 1.2 | 1065 | 153 | 186 | 6 | 126 | 20 | 58 | 111 |
| Granite of Rich Hill | H | 71 | 0.5 | 577 | 87 | 63 | 19 | 37 | 21 | 22 | 40 |

than Crazy Basin. The pluton is named for exposures on Lane Mountain, about 4 miles south of Crown King. The granodiorite is poorly exposed in the southern Crown King area. Contacts of the granodiorite with Crazy Basin are approximate but correspond closely to the 2600-gamma contour on the aeromagnetic map of the Bradshaw Mountains (U.S. Geological Survey, 1972). The body is very similar in major-element chemistry to the southern part of the Crooks Canyon Granodiorite (figs. 2, 4, and 5). Minor-element concentrations, especially very low Y and relatively low Rb, La, and Ce, also are very similar to the southern part of Crooks Canyon.

*Granite of Rich Hill (new informal name).* This equigranular, calc-alkalic to alkali-calcic muscovite-biotite granite southeast of Yarnell is the most leucocratic rock in the region. The pluton is named for Rich Hill, about 4 miles southeast of Yarnell. The northeastern extension of the body has not been mapped, but may be gradational into the southern part of the Crooks Canyon Granodiorite southwest of Wagoner. The western part of the granite is situated over a 300-gamma magnetic high (U.S. Geological Survey, 1972) believed to be caused by magnetic lithologies in the older metavolcanic terrane, not by the weakly magnetic granite. The granite also is on the southeast shoulder of a 400-gamma magnetic high caused by the granodiorite of Yarnell and could be underlain by that highly magnetic granodiorite. The granite is mildly foliated, but late felsic differentiates do not appear to be as foliated as the medium-grained granite. Minor-element concentrations of the granite are variable (tables 2 and 3) but similar to those in the granodiorite of Lane Mountain and the southern part of Crooks Canyon. Quite possibly more than one leucocratic pluton may be present in the area southeast of Yarnell. The most leucocratic units of Rich Hill are depleted in Zr, Y, Ce, and La compared to the main granite and appear to be aplitic phases of the granite.

**Suite 2: Pre- to syntectonic hornblende-biotite tonalite and granodiorite plutons (metaluminous, high Sr, high magnetite).**

*Tonalite of Cherry (new informal name).* This equigranular, calc-alkalic to calcic hornblende-biotite tonalite to granodiorite (quartz diorite of Anderson and Creasey, 1958) is undeformed in the center and east, but tectonically foliated in the west. Granophyre associated with the tonalite is also calc-alkalic to calcic (figs. 2 and 3). However, this granophyre is also strongly peraluminous (table 1), which raises questions about deuteric alteration of the granophyre during late-stage crystallization. The tonalite is magnesium rich, but the granophyre is iron rich, a possible consequence of fractional crystallization of the granophyre from a tonalitic magma. The informal name is taken from Cherry, about 12 miles south of Jerome and 10 miles east of Camp Verde. The pluton was intruded 1740 ± 15 Ma (Anderson and others, 1971) and cooled rapidly to <250° C by 1685 to 1690 Ma (Lanphere, 1968, Dalrymple and Lanphere, 1974). Other 1700-Ma plutons to the west such as Brady Butte and the Prescott Granodiorite either were deeply buried or were reheated at or prior to 1300 Ma (Marvin and Cole, 1978). A swarm of north-trending granodiorite porphyry dikes cuts the tonalite of Cherry; these dikes may be genetically related to the Badger Spring Granodiorite as suggested below. The tonalite averages 7.0 percent magnetite, second in abundance only to the granodiorite of Yarnell. Much of the outcrop area of the tonalite, however, is not an aeromagnetic high as might be expected, but is magnetically similar to the metavolcanic terrane it intrudes (Dempsey and others, 1963; U.S. Geological Survey, 1972). Either the tonalite is a thin, sheetlike body, or it is reversely polarized to account for the lack of an associated magnetic high. The tonalite of Cherry is distinguished from other plutons of this group by its low concentrations of Rb, Zr, La, and Ce. Y is low in all plutons of this group. A peculiar feature of the tonalite is that rocks that contain the most Sr contain the least Fe, a trend not found in most 1700-1750-Ma plutons studied.

*Government Canyon Granodiorite (Krieger, 1965).* This equigranular, alkali-calcic hornblende-biotite tonalite is megascopically similar to the tonalite of Cherry, is predominantly massive, but in places possesses a mild tectonic foliation. The tonalite is 1750 ± 15 Ma (Anderson and others, 1971), an age indistinguishable from that of the tonalite of Cherry. Government Canyon is one of the most magnesium-rich plutons studied (fig. 4), comparable only to the Prescott Granodiorite discussed below. Magnetite concentration averages 4.5 percent, similar to the Prescott Granodiorite, but much of the outcrop area of Government Canyon is not a pronounced aeromagnetic high (Aero Services, 1983). This feature of Government Canyon is similar to the magnetic signature of the tonalite of Cherry. Government Canyon has the highest Sr concentration of any studied pluton (fig. 6) and is characterized by low Rb and Y, a distinctive feature of all plutons of this group. Both Government Canyon and the tonalite of Cherry could be interpreted as the tonalite part of the "trondhjemite-tonalite" suite of Barker (1979).

*Granodiorite of Wilhoit (Anderson, 1986a, this volume).* A large body of equigranular biotite-hornblende granodiorite containing distinctive, hexagonal plates of biotite extends from south of Yarnell to west of Prescott and underlies much of Peeples Valley (fig. 1). The granodiorite is mildly foliated in most exposures but appears more massive in isolated outcrops. West of Prescott the granodiorite intrudes the Government Canyon Granodiorite, but north of U.S. Highway 89 the granodiorite may be a leucocratic core phase of Government Canyon. The granodiorite is named for exposures near Wilhoit and in Peeples Valley, north of Yarnell, where the western edge of the pluton is a north-trending belt of metavolcanic rocks. North of Wagoner the Crooks Canyon Granodiorite intrudes the granodiorite as a massive swarm of leucocratic dikes and aplite bodies. The granodiorite, as used here, is a single

intrusive body, not a composite of a number of plutonic units as used by Anderson (1986a).

Chemical data are largely lacking for the granodiorite of Wilhoit. Sample 7A (fig. 1) may be from a rock of similar composition, an alkali-calcic granodiorite. Leucocratic varieties of the pluton are somewhat unusual for suite 2 rocks because of their low concentration of magnetite (~0.8 percent), but normal to mafic varieties of the pluton average 3.5-5 percent magnetite. The pluton is shown as an alkali-calcic body on figure 1 because of its megascopic similarity to leucocratic phases of the Government Canyon Granodiorite.

*Prescott Granodiorite (Krieger, 1965).* This equigranular to slightly porphyritic, calc-alkalic biotite granodiorite intrudes the Government Canyon Granodiorite and is undeformed. Some of the covered area northeast of Prescott may be underlain by this granodiorite (fig. 1), but northwest-trending magnetic highs and lows (Dempsey and others, 1963) that appear to represent buried metavolcanic lithologies indicate that not all the covered area is Prescott Granodiorite. The granodiorite has a relatively high percentage of magnetite (4.2 percent), is strongly magnesium rich, and is moderately peraluminous (table 3), an unusual feature for a rock of this nature. The moderately peraluminous nature appears to be due to slightly elevated alumina concentration, not a loss of alkali elements. The Prescott Granodiorite has relatively high Ba (highest in this suite) and Sr and low Y, characteristic features for plutons of this group. The granodiorite could have been derived from a magma similar to that of the Government Canyon Granodiorite by fractional crystallization.

**Suite 3: Pre- to late-tectonic biotite-hornblende granodiorite plutons (metaluminous, low Rb, Zr, La, and Ce, very low Sr, and low magnetite).**

*Bumblebee Granodiorite (Anderson and Blacet, 1972c).* This equigranular, calcic hornblende granodiorite intrudes metavolcanic units along and west of the Agua Fria River (fig. 1). Most of the Bumblebee is undeformed, but its western margin is tectonically foliated, indicating that the granodiorite is pretectonic to late tectonic. The border phase of the granodiorite, as mapped by Anderson and Blacet (1972b), is a diorite (fig. 2) that is iron rich (fig. 4), compared to the magnesium-rich main phase of the granodiorite. This reverse zoning of iron and magnesium may indicate that two separate plutons may be present instead of one. Also, dioritic to gabbroic sills and hypabyssal intrusive bodies related to the metavolcanic terrane are typically iron rich (DeWitt, unpub. data, 1986), indicating that the border phase of the Bumblebee may be older than the main granodiorite and not related to it. The granodiorite has low concentrations of Rb, La, and Ce, and is representative of this group of rather primitive plutons that have trace-element concentrations very similar to gabbro bodies that intrude the metavolcanic terrane (fig. 6).

*Quartz Diorite of Bland (Jerome, 1956).* A large body of equigranular hornblende-biotite quartz diorite, most of which is southeast of figure 1, intrudes metavolcanic rocks along Interstate highway 17. Jerome (1956) and Winn (1982) noted the highly foliated nature of much of the body, which has a U-Pb zircon age of 1720 Ma (Bowring and others, 1986). All textural and compositional phases of the body have very low magnetite concentrations averaging 0.2 percent. Major- and minor-element chemistry is lacking for the quartz diorite, but the pluton is shown as a calcic body on figure 1 because of its mineralogic similarity to the Bumblebee Granodiorite. The Badger Spring Granodiorite intrudes the quartz diorite but may be genetically related to it.

*Badger Spring Granodiorite (Anderson and Blacet, 1972c).* This porphyritic (quartz phenocrysts), calcic granodiorite intrudes the Bumblebee and is undeformed except locally along its western margin. Much of its plagioclase is altered to clinozoisite plus sericite, indicating that the pluton has been regionally metamorphosed or deuterically altered. The north-trending granodiorite porphyry dike swarm that cuts the tonalite of Cherry (Anderson and Creasey, 1967) is believed to be derived from this granodiorite because an analysis of one dike plots in the Badger Spring field in figure 2. For a pluton with a $SiO_2$ concentration of 70-72 percent, the Badger Spring has a very primitive minor element signature of low Rb, La, and Ce, and plots next to the Bumblebee in the field of gabbro bodies related to the metavolcanic terrane. The area along Interstate Highway 17 occupied by the Bumblebee and Badger Spring plutons coincides with a broad, low-amplitude magnetic low (U.S. Geological Survey, 1972). The 2400-gamma contour may approximately coincide with the buried contact of these plutons with the tonalite of Cherry.

**Suite 4: Syn- to posttectonic biotite granodiorite to granite plutons (metaluminous, high Ba, Rb, Zr, La, and Ce, moderate to high magnetite).**

*Granodiorite of Yarnell (new informal name).* This equigranular to slightly porphyritic, alkali-calcic biotite granodiorite is the westernmost foliated pluton in the study area and is named for exposures near Yarnell. The extent of the pluton to the northwest is poorly known; some of what is shown as granodiorite of Yarnell on figure 1 may turn out to be an alkali-calcic granite that occupies much of the high country of the Weaver Mountains (DeWitt, unpub. data, 1986). The granodiorite is relatively massive in the east but is progressively more deformed and slightly more mafic to the west. The Yarnell intrudes metavolcanic and metasedimentary rocks and the granodiorite of Wilhoit. Although the pluton is undated, it is assumed to be 1700-1750 Ma because of its foliated nature. L.T. Silver (personal commun., 1986) suggested on the basis of unpublished U-Pb zircon data that the granodiorite may be 1400 Ma; if so, it should be removed from suite 4. The granodiorite is the most magnetic rock in the region, averaging 8.0 percent magnetite, and coincides with a northeast-trending, 400-gamma magnetic high that extends

from Yarnell to the southwest for 10 miles (Aero Services, 1983; Sauck and Sumner, 1970). Another distinguishing feature is the moderately iron-rich nature of the pluton (fig. 4), a characteristic restricted to this group of plutons. The granodiorite of Yarnell is more evolved than all previously described rocks even though it is a relatively mafic granodiorite. The trace-element signature of high Rb, Ba, and the highest Y (45 ppm), Zr (280 ppm), Nb (25 ppm), La (82 ppm), and Ce (164 ppm) of any pluton described so far distinguishes this granodiorite. Only the granite of Iron Springs, to be described later, has similar concentrations of incompatible minor elements. Apparently the granodiorite was derived from a magma much more enriched in incompatible minor elements than plutons of other suites. Although both the northern part of the Crooks Canyon Granodiorite and the granodiorite of Yarnell have high Y, Nb, Zr, La, and Ce, Crooks Canyon does not appear to be related to the latter because of the low Rb and Sr concentrations of Crooks Canyon.

*Granite of Iron Springs (new informal name).* This coarsely porphyritic (microcline phenocrysts), alkali-calcic biotite granite, named for exposures at Iron Springs, 8 miles northwest of Prescott, is typical of plutons thought to be the youngest in the 1700-1750-Ma group. Most of the granite is massive and undeformed, but northeast-trending mylonitic zones that cut the pluton on its western side attest to a late-tectonic (~1700 Ma) age for the body. Even though the coarsely porphyritic texture of the granite is similar to anorogenic 1400-Ma plutons in Arizona (Silver and others, 1977), the relatively high concentration of magnetite (5.3 percent), low radiometric signature, and deformed nature of the pluton indicate that the granite is not 1400 Ma. The granite contains the highest concentration of Ba, La, and Ce, and plots well away from any other pluton in figure 6. The minor-element signature of the granite is very similar to the granodiorite of Yarnell, and both could have crystallized from a magma of similar chemistry. Another feature that supports the late 1700-Ma age of the granite is its high Sr concentration (400-500 ppm). Anorogenic 1400-Ma plutons in the southwest having Sr concentrations greater than 350 ppm have not been recognized, with the exception of the unusually potassic granite of Hualapai Peak near Kingman, Arizona (Kesler, 1976; J.L. Anderson, this volume).

*Granodiorite of Hozoni Ranch (new informal name).* A moderately porphyritic (microcline phenocrysts), mildly foliated, calc-alkalic biotite-hornblende granodiorite appears to intrude the granodiorite of Minnehaha near Hozoni Ranch, southeast of Wagoner. The pluton forms a large body extending toward Wickenburg south of figure 1 (DeWitt, unpub. mapping, 1987) and is described in this section because it is representative of plutons of this suite. The granodiorite is similar in major-element chemistry to the granite of Iron Springs but contains less $K_2O$ (fig. 5) and Rb (fig. 6). Trace-element concentrations of this granodiorite are very similar to the granite of Iron Springs and the granodiorite of Yarnell.

*Crazy Basin Quartz Monzonite (Blacet, 1968; Anderson and Blacet, 1972b).* This distinctive, equigranular to slightly porphyritic (microcline phenocrysts), undeformed, alkali-calcic biotite ± muscovite granite is the only pluton studied that intrudes predominantly metasedimentary rocks. Extensive cogenetic pegmatite swarms intrude both metasedimentary rocks and the granodiorite of Lane Mountain. Regional metamorphic grade of the wall rocks increases substantially adjacent to the pluton (Blacet, 1968; DeWitt, 1976; Blacet, 1985), indicating that the pluton was emplaced late during regional metamorphism and deformation. The granite has a Rb-Sr whole-rock model date of 1610 ± 90 Ma (Marvin and Cole, 1978) and a U-Pb zircon date of 1700 Ma (Bowring, Sam, unpub. data, 1986; discussed by Karlstrom and Conway, 1986). The granite is noteworthy because of its moderately peraluminous nature, its moderate to strong iron enrichment, and low (0.5 percent) magnetite concentration. Aeromagnetic lows coincide with the northern and eastern parts of the granite (U.S. Geological Survey, 1972). The granite is the most Rb-rich rock of any pluton studied but contains rather low Y, La, and Ce compared to other plutons of this suite. The pluton appears to have been derived from a magma slightly depleted in all the incompatible trace elements determined except Rb. Alternatively the granite could have been derived from a magma similar to that of the granite of Iron Springs by extensive plagioclase crystal fractionation.

## DISCUSSION

The 1700-1750-Ma plutons of north-central Arizona show a great range in major- and minor-element geochemistry, from rocks characteristic of primitive magmas to those characteristic of evolved magmas. Because all the plutons (except Crazy Basin Quartz Monzonite) intrude 1720-1780-Ma mafic to felsic metavolcanic rocks (Anderson and others, 1971), the ultimate source of their parental magmas was either the volcanic rocks themselves or the presumed underlying oceanic mantle. Therefore, compositions of the plutons should be a reflection of their source, depth and degree of partial melting, and processes leading to their formation. Ideally, additional data such as initial Sr and Pb isotopic ratios and rare-earth element analyses should be employed in this discussion, but these data are not available. However, if plutons of a specific age and geochemical suite are considered, some very important tectonic features are noted.

In the Prescott region (fig. 1), a distinct alkalinity trend is noted for the 1700-1750-Ma plutons. Calcic rocks are restricted to the east and southeast areas, predominantly southeast of Mayer. Calc-alkalic rocks are present in a northeast-trending central belt, between Prescott and Mayer. Alkali-calcic rocks are present only in the west and

northwest parts of the region. The only major exception to this trend is the Crazy Basin Quartz Monzonite, which will be discussed below. The trend of increasing alkalinity to the northwest is also evident for K, Rb, and most of the incompatible minor elements. At constant $SiO_2$, $K_2O$ increases to the northwest, from values as low as 0.8 percent for the tonalite of Cherry and the Badger Spring Granodiorite ($SiO_2$ = 66-70 percent) to greater than 4.5 percent for the granite of Iron Springs (fig. 5). At constant $FeO_t$ (used instead of $SiO_2$ for minor-element plots because $SiO_2$ analyses are not available for all minor-element determinations), Rb increases from values as low as 10-30 ppm for the tonalite of Cherry and the Badger Spring Granodiorite to values as high as 160 ppm for the granite of Iron Springs (fig. 6). Although not shown in separate figures, Zr, Y, and Ce, at constant $FeO_t$, also increase to the northwest for the three plutons above as follows: Zr from between 60 and 90 ppm in the southeast to 280 ppm in the northwest; Y from 5-15 ppm in the southeast to 30-50 ppm in the northwest; Ce from 25-35 ppm in the southeast to 160 ppm in the northwest. Minor local reversals of this trend are noted for a few plutons in the calc-alkalic central belt, but those reversals do not invalidate the regional trend.

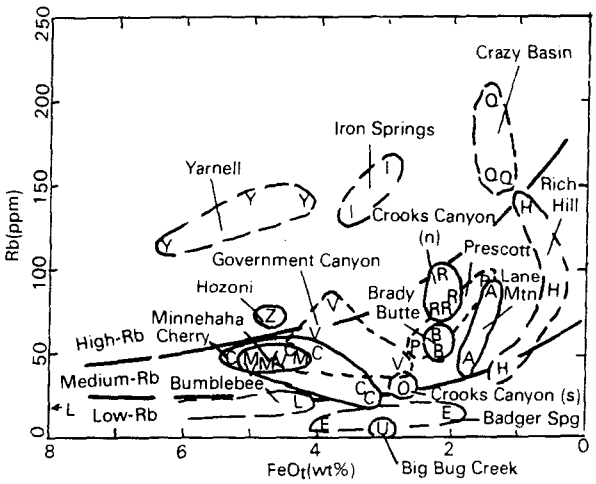



Figure 7. Rb versus $FeO_t$ diagram for 1700-1750-Ma plutonic rocks, north-central Arizona. Low-Rb (low-K), medium-Rb (medium-K), and high-Rb (high-K) field boundaries constructed from those in figure 5. Plotting symbols as in figure 2.

The trend of increasing alkalinity and incompatible minor elements from southeast to northwest is strengthened if plutons of exactly the same age and similar major-element chemistry are considered. Examples from different suites are given below.

*Suite 1 biotite granodiorite plutons.* The Brady Butte Granodiorite (1750 ± 10 Ma, pretectonic), granodiorite of Minnehaha (pretectonic), and granodiorite of Big Bug Creek (pretectonic) have similar major-element compositions (fig. 2), are all highly foliated, and have very low magnetite concentrations (table 3). The granodiorite of Minnehaha is slightly more calcic than the other two bodies. Even though their major-element chemistry is similar, the plutons have different minor-element chemistry. The granodiorite of Big Bug Creek has the lowest total alkalis (fig. 3) and $K_2O$ (fig. 5) and the lowest Rb (fig. 6) and Ba. Both Brady Butte and the granodiorite of Minnehaha are more alkali rich and have higher $K_2O$, Rb, Ba, La, and Ce concentrations. Therefore, at constant $SiO_2$, alkalinity and incompatible minor elements increase to the northwest.

*Suite 1 leucocratic granodiorite-granite plutons.* Leucocratic calc-alkalic granodiorite bodies similar in age to, or slightly younger than, the Brady Butte Granodiorite show the same trend. The southern part of the Crooks Canyon Granodiorite (pretectonic) and the granodiorite of Lane Mountain (pretectonic) have similar major- and minor-element compositions. Northwest of these bodies are the northern part of Crooks Canyon (pretectonic) and the granite of Rich Hill (pretectonic), which are more alkalic, have higher $K_2O$, Rb, Ba, Y, Zr, Nb, La, and Ce concentrations. Again, alkalinity and incompatible minor elements increase to the northwest.

*Suite 2 hornblende tonalite plutons.* The tonalite of Cherry (1740 ± 15 Ma) and the Government Canyon Granodiorite (1750 ± 15 Ma) are pre- to syntectonic, are both tonalitic, and have high concentrations of magnetite. At constant $SiO_2$, however, Government Canyon is much more alkalic, has higher $K_2O$, slightly higher Rb, and higher Zr, La, and Ce. Alkalinity and incompatible minor elements again increase to the northwest.

*Suite 4 biotite-muscovite granite plutons.* The only plutonic body that appears to violate the above trend is the Crazy Basin Quartz Monzonite, an alkali-calcic, high-$K_2O$, high-Rb pluton of suite 4 that crops out far to the southeast of other plutons in the suite. As noted above, Crazy Basin is the only pluton that intrudes predominantly metasedimentary rocks and is the only pluton in suite 4 that is peraluminous. Quite possibly the granite was derived from partial melting of a metasedimentary source (high $K_2O$, Rb; relatively low La, Ce, Zr) instead of a predominantly metavolcanic source inferred for all other plutons.

This trend of increasing incompatible minor elements to the northwest is also noted if the total of Ba, Rb, and Sr is plotted against $FeO_t$ (fig. 8). These trace elements are combined because they are concentrated preferentially in the feldspars (microcline, orthoclase, plagioclase) in any oceanic arc or mantle source. Therefore, the amount of Ba + Rb + Sr in an arc-related magma will qualitatively reflect the amount and minor-element concentration of feldspar that was partially melted to form the magma. If the source material was relatively constant in composition (immature volcanic arc material or mantle wedge), and the amount of Ba, Rb, and Sr in plutons that intrude the arc increase to the northwest, the degree of partial melting may have increased to the northwest. If the source material varied in composition from southeast to northwest, an interpretation of increasing alkalinity and incompatible minor elements to the northwest would be more complex.

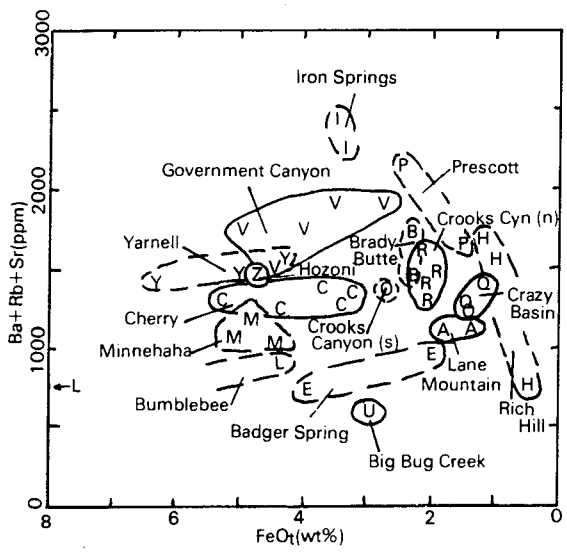



Figure 8. Ba+Rb+Sr versus $FeO_t$ diagram for 1700-1750-Ma plutonic rocks, north-central Arizona. Plotting symbols as in figure 2.

In modern and Phanerozoic island arcs and Andean arcs, total alkalis ($Na_2O + K_2O$) and incompatible trace elements (Ba, Rb, Zr, U) increase in concentration across the strike of the arc and continentward away from the subduction zone (Dickinson, 1975; Keith, 1978; Ewart, 1979; Gill, 1981). Although the causes for this increase are varied (see discussion in Gill, 1981), the empirical relationship is valid, which enables the polarity of modern and Phanerozoic subduction zones and magmatic arcs to be determined. The 1700-1750-Ma plutons of this study have a pronounced increase of alkalinity and incompatible minor elements from southeast to northwest, and indicate a distinct polarity for the physical process that formed the magmas. That process may well have been subduction of oceanic crust from the southeast toward the northwest (northwest-dipping oceanic slab).

If the remains of a paleosubduction zone are to be found, they must lie to the southwest of figure 1, at least 60 km and up to 100 km away. The actual location of such a trench would depend on the dip of the subduction zone, but for an average dip of 45-60 degrees such a subduction zone would have been located near the present site of Globe or Superior, Arizona. Emplacement of the 1400-Ma Ruin Granite (see J.L. Anderson, this volume) has obliterated most evidence for such a subduction zone in that area. Farther south in the Johnny Lyon Hills and Little Dragoon Mountains, Swift (1986) recognized melange deformation in the Pinal Schist, a predominantly pelitic to quartzose metasedimentary unit. The Pinal Schist in that area is older than 1680-1700 Ma (Silver, 1978), and may be similar in age to the suite 4 plutonic rocks in the Prescott area. Conceivably, the melange character noted above may be an indication of an active continental margin between Globe and the Little Dragoon Mountains at about 1700 Ma. Condie and DeMalas (1985) did not note melange textures in Pinal Schist turbidite lithologies in southeast Arizona, but their suggestion of either marine rift-related or active basin settings could be accommodated in a passive continental margin being subducted to the northwest at about 1700 Ma.

## REFERENCES


Aero Services, 1983, Residual intensity magnetic anomaly contour map, plate 4 of Prescott quadrangle [Arizona]: U.S. Department of Energy Open-File Map GJM-430, available from U.S. Geological Survey, Open-File Services Section, P.O. Box 25425, Denver, CO 80225, scale 1:250,000.

Anderson, C.A., 1972, Precambrian rocks in the Cordes area, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1345, 36 p.

Anderson, C.A., and Blacet, P.M., 1972a, Geologic map of the Mount Union quadrangle, Yavapai County, Arizona: U.S. Geological Survey Geologic Quadrangle Map GQ-997, scale 1:62,500.

Anderson, C.A., and Blacet, P.M., 1972b, Precambrian geology of the northern Bradshaw Mountains, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1336, 82 p.

Anderson, C.A., and Blacet, P.M., 1972c, Geologic map of the Mayer quadrangle, Yavapai County, Arizona: U.S. Geological Survey Geologic Quadrangle Map GQ-996, scale 1:62,500.

Anderson, C.A., and Creasey, S.C., 1958, Geology and ore deposits of the Jerome area, Yavapai County, Arizona: U.S. Geological Survey Professional Paper 308, 185 p.

Anderson, C.A., and Creasey, S.C., 1967, Geologic map of the Mingus Mountain quadrangle, Yavapai County, Arizona: U.S. Geological Survey Map GQ-715, scale 1:62,500.

Anderson, C.A., and Nash, J.T., 1972, Geology of the massive sulfide deposits at Jerome, Arizona—A reinterpretation: Economic Geology, v. 67, p. 845-863.

Anderson, C.A., and Silver, L.T., 1976, Yavapai Series—A greenstone belt, *in* Wilt, J.C., and Jenney, J.P., eds., Tectonic Digest: Arizona Geological Society Digest, v. 10, p. 13-26.

Anderson, C.A., Blacet, P.M., Silver, L.T., and Stern, T.W., 1971, Revision of the Precambrian stratigraphy in the Prescott-Jerome area, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1324-C, p. C1-C16.

Anderson, J.L., 1983, Proterozoic anorogenic granite plutonism of North America, *in* Medaris, L.G. Jr., Byers, C.W., Mickelson, D.M., and Shanks, W.C., eds., Proterozoic geology; selected papers from an international Proterozoic symposium: Geological Society of America Memoir 161, p. 133-154.

Anderson, Phillip, 1978, The island arc nature of Precambrian volcanic belts in Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 10, no. 3, p. 156.

Anderson, Phillip, 1986a, The Proterozoic tectonic evolution of Arizona: Tucson, University of Arizona, Ph.D. dissertation, 416 p.

Anderson, Phillip, 1986b, Summary of the Proterozoic plate tectonic evolution of Arizona from 1900 to 1600 Ma, *in* Beatty, Barbara, and Wilkinson, P.A.K., eds., Frontiers in geology and ore deposits of Arizona and the Southwest: Tucson, Arizona Geological Society Digest, v. 16, p. 5-11.

Arth, J.G., and Hanson, G.N., 1975, Geochemistry and origin of the early Precambrian crust of northeastern Minnesota: Geochimica et Cosmochimica Acta, v. 39, p. 325-362.

Barker, Fred, 1979 (ed.), Trondhjemites, dacites, and related rocks: Developments in Petrology 6, Elsevier, New York, 659 p.

Blacet, P.M., 1966, Unconformity between gneissic granodiorite and overlying Yavapai Series (older Precambrian), central Arizona: U.S. Geological Survey Professional Paper 550-B, p. 1-5.

Blacet, P.M., 1968, Precambrian geology of the SE 1/4 Mount Union quadrangle, Bradshaw Mountains, central Arizona: Stanford, Stanford University, Ph.D. dissertation, 244 p.

Blacet, P.M., 1985, Proterozoic geology of the Brady Butte area, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1548, 55 p.

Bowring, Sam, 1986, Unpublished data: St. Louis, Washington University.

Bowring, Sam, Karlstrom, K.E., and Chamberlain, K., 1986, U-Pb zircon constraints on Proterozoic tectonic evolution in central Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 343.

Bryant, Bruce, and Wooden, J.L., 1986, Early and Middle Proterozoic history of the Poachie Range, Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 344.

Condie, K.C., and DeMalas, J.P., 1985, The Pinal Schist: an Early Proterozoic quartz wacke association in southeastern Arizona: Precambrian Research, v. 27, p. 337-356.

Conway, C.M., 1976, Petrology, structure, and evolution of a Precambrian volcanic and plutonic complex, Tonto Basin, Gila County, Arizona: Pasadena, California Institute of Technology, Ph.D. dissertation, 460 p.

Dalrymple, G.B., and Lanphere, M.A., 1974, $^{40}Ar/^{39}Ar$ spectra of some undisturbed terrestrial samples: Geochimica et Cosmochimica Acta, v. 38, p. 715-738.

De la Roche, H., Leterrier, J., Grandclaude, P., and Marchal, M., 1980, A classification of volcanic and plutonic rocks using $R_1R_2$-diagram and major-element analyses—its relationships with current nomenclature: Chemical Geology, v. 29, p. 183-210.

Dempsey, W.J., Hill, M.E., and others, 1963, Aeromagnetic map of central Yavapai County, Arizona, including the Jerome mining district: U.S. Geological Survey Geophysical Investigations Map GP-402, scale 1:62,500.

DeWitt, Ed, 1976, Precambrian geology and ore deposits of the Mayer-Crown King area, Yavapai County, Arizona: Tucson, University of Arizona, M.S. thesis, 150 p.

DeWitt, Ed, 1979, New data concerning Proterozoic volcanic stratigraphy and structure in central Arizona and its importance in massive sulfide exploration: Economic Geology, v. 74, p. 1371-1382.

DeWitt, Ed, 1986, Geochemistry and tectonic polarity of 1700-1750 Ma plutons, north-central Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 351.

DeWitt, Ed, 1986, Unpublished data: Denver, U.S. Geological Survey.

Dickinson, W.R., 1975, Potash-depth (K-h) relations in continental margin and intra-oceanic magmatic arcs: Geology, v. 3, p. 53-56.

Dodge, F.C.W., Millard, H.T., and Elsheimer, H.N., 1982, Compositional variations and abundances of selected elements in granitoid rocks and constituent minerals, central Sierra Nevada Batholith, California: U.S. Geological Survey Professional Paper 1248, 24 p.

Ewart, A., 1979, A review of the mineralogy and chemistry of Tertiary-Recent dacitic, latitic, rhyolitic, and related salic volcanic rocks, *in* Barker, Fred, ed., Trondhjemites, dacites, and related rocks: Developments in Petrology 6, Elsevier, New York, p. 13-122.

Gill, James, 1981, Orogenic andesites and plate tectonics: Springer-Verlag, New York, 390 pgs.

Hook, D.L., 1956, Late Cenozoic stratigraphy and structure of the Walnut Grove Basin, Yavapai County, Arizona: Tucson, University of Arizona, M.S. thesis, 34 p.

Jaggar, T.A., and Palache, Charles, 1905, Description of Bradshaw Mountains quadrangle, Arizona: U.S. Geological Survey Atlas folio 126, 11 p.

Jerome, S.E., 1956, Reconnaissance geologic study of the Black Canyon schist belt, Bradshaw Mountains, Yavapai and Maricopa Counties, Arizona: Salt Lake City, University of Utah, Ph.D. dissertation, 160 p.

Karlstrom, K.E., and Conway, C.M., 1986, Deformational styles and contrasting lithostratigraphic sequences within an Early Proterozoic orogenic belt, central Arizona, *in* Nations, J.D., Conway, C.M., and Swann, G.A., eds., Geology of central and northern Arizona: Geological Society of America, Rocky Mountain Section Guidebook, p. 1-26.

Karlstrom, K.E., and O'Hara, P.F., 1984, Polyphase folding in Proterozoic rocks of central Arizona (abs.): Geological Society of America Abstracts with Programs, v. 16, no. 4, p. 226.

Keith, S.B., 1978, Paleosubduction geometries inferred from Cretaceous and Tertiary magmatic patterns in southwestern North America: Geology, v. 6, p. 516-521.

Keith, S.B., 1986, Petrochemical variations in Laramide magmatism and their relationships to Laramide tectonic and metallogenic evolution in Arizona and adjacent regions, *in* Beatty, Barbara and Wilkinson, P.A.K., eds., Frontiers in geology and ore deposits of Arizona and the Southwest: Tucson, Arizona Geological Society Digest, v. 16, p. 89-101.

Kesler, E.J., 1976, Rubidium-strontium geochronology and trace element geochemistry of Precambrian rocks in the northern Hualapai Mountains, Mohave County, Arizona: Tucson, University of Arizona, M.S. thesis, 73 p.

Krieger, M.H., 1965, Geology of the Prescott and Paulden quadrangles, Arizona: U.S. Geological Survey Professional Paper 467, 127 p.

Krieger, M.H., 1967, Reconnaissance geologic map of the Iron Springs quadrangle, Yavapai County, Arizona: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-504, scale 1:62,500.

Lanphere, M.A., 1968, Geochronology of the Yavapai Series of central Arizona: Canadian Journal of Earth Sciences, v. 5, p. 763-772.

Lee, D.E., 1984, Analytical data for a suite of granitoid rocks from the Basin and Range Province: U.S. Geological Survey Bulletin 1602, 54 p.

Light, T.D., 1975, Geology of the Board Creek area, Yavapai County, Arizona: Flagstaff, Northern Arizona University, M.S. thesis, 61 p.

Lindgren, Waldemar, 1926, Ore deposits of the Jerome and Bradshaw Mountains quadrangles, Arizona: U.S. Geological Survey Bulletin 782, 192 p.

Ludwig, K.R., 1973, Precambrian geology of the central Mazatzal Mountains, Arizona: Pasadena, California Institute of Technology, Ph.D. dissertation, Part I, 218 p.

Marvin, R.F., and Cole, J.C., 1978, Radiometric ages: Compilation A, U.S. Geological Survey: Isochron/West, no. 22, p. 5-14.

Miyashiro, A., 1974, Volcanic rocks series in island arcs and active continental margins: American Journal of Science, v. 274, p. 321-355.

O'Hara, P.F., Yoder, M.P., Stamm, C.A., Niver, Randall, and Maliga, Jody, 1978, The Precambrian Texas Gulch Formation boundary fault system, Yavapai County, Arizona—A folded unconformity? [abs.]: Geological Society of America Abstracts with Programs, v. 10, no. 3, p. 140.

Peacock, M.A., 1931, Classification of igneous rock series: Journal of Geology, v. 39, p. 54-67.

Peccerillo, A., and Taylor, S.R., 1976, Geochemistry of Eocene calc-alkaline volcanic rocks from the Kastamonu area, northern Turkey: Contributions to Mineralogy and Petrology, v. 58, p. 63-81.

Pflafker, Lloyd, 1956, Geologic reconnaissance of the Cenozoic Walnut Grove Basin, Yavapai County, Arizona: Tucson, University of Arizona, M.S. thesis, 53 p.

Sauck, W.A., and Sumner, J.S., 1970, Residual aeromagnetic map of Arizona: Tucson, The University of Arizona, Department of Geosciences, scale 1:1,000,000.

Shand, S.J., 1927, The Eruptive Rocks: John Wiley and Sons, New York, 488 p.

Silver, L.T., 1968, Precambrian batholiths of Arizona [abs.]: Geological Society of America Special Paper 121, p. 558-559.

Silver, L.T., 1978, Precambrian formations and Precambrian history in Cochise County, southeastern Arizona, *in* Callender, J.F., Wilt, J.C., and Clemons, R.E., eds., Land of Cochise: Socorro, New Mexico Geological Society Guidebook, 29th Field Conference, p. 157-163.

Silver, L.T., 1986, Personal communication: Pasadena, California Institute of Technology.

Silver, L.T., Conway, C.M., and Ludwig, K.R., 1986, Implications of a precise chronology for early Proterozoic crustal evolution and caldera formation in the Tonto Basin-Mazatzal Mountains region, Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 413.

Silver, L.T., Bickford, M.E., Van Schmus, W.R., Anderson, J.L., Anderson, J.H., and Medaris, L.G. Jr., 1977, The 1.4-1.5 b.y. transcontinental anorogenic plutonic perforation of North America [abs.]: Geological Society of America Abstracts with Programs, v. 9, no. 7, p. 1176-1177.

Steiger, R.H., and Jaeger, Emile, 1977, Subcommission on geochronology: convention and use of decay constants in geo- and cosmochronology: Earth and Planetary Sciences Letters, v. 36, p. 359-362.

Swift, P.N., 1986, Melange deformation in the Pinal Schist: structures and possible implications [abs.]: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 417.

U.S. Geological Survey, 1972, Aeromagnetic map of the Bradshaw Mountains and vicinity, Yavapai County, Arizona: U.S. Geological Survey Geophysical Investigations Map GP-758, scale 1:62,500.

Vrba, S.L., 1980, Precambrian geology of the Cleator area, Yavapai County, Arizona: Flagstaff, Northern Arizona University, M.S. thesis, 96 pgs.

Winn, P.S., 1982, Structure and petrology of Precambrian rocks in the Black Canyon area, Yavapai County, Arizona: Salt Lake City, University of Utah, M.S. thesis, 101 p.

Wolfe, E.W., 1983, Geologic map of the Arnold Mesa Roadless Area, Yavapai County, Arizona: U.S. Geological Survey Miscellaneous Field Studies Map MF-1577-B, scale 1:24,000.

Revised manuscript accepted 1987.

JDS

**ASARCO**

**Southwestern Exploration Division**

July 13, 1990

W.L. Kurtz

Malusa's Report
Altered vs. Unaltered Granite
Yarnell Project
Yavapai County, Arizona

A wrap-up of some of the whole-rock values available at Yarnell.

Should the project area be turned into a thesis area, then I'm sure additional whole-rock data may come forth, but Exploration will let it lie as is for now.

James D. Sell

James D. Sell

JDS:mek
Att.

cc: J.J. Malusa
M.A. Miller

ASARCO

Southwestern Exploration Division

JDS

July 10, 1990

J.D. Sell

Whole-rock Values
Altered vs. Unaltered
Granite
Yarnell Project
Yavapai County, AZ

Summary and Conclusion

With respect to major mineral forming elements, the most significant difference between unaltered and altered granite is seen in the increase of $K_2O$ concentrations and the decrease in $Na_2O$ and $Fe_2O_3$ + FeO concentrations in altered footwall granite as compared to unaltered footwall and hanging wall granite.

Study

Whole rock analyses have been received for altered (sample obtained from core hole YDDH-1 at 320') and unaltered (sample locations of unaltered granite included in reported titled Whole Rock Analysis, March 19, 1990) granite from the Yarnell area. Appendix A lists the weight percent oxide abundances and normative abundances of the samples. These values were then used to construct two ternary diagrams labelled Attachment 1 and 2. Also, a listing of major mineral forming elements with substantial variation between unaltered and altered granite has been tabulated in Table 1 for quick reference.

Table 1. Weight % $K_2O$, $Na_2O$, $K_2O/Na_2O$, $Fe_2O_3$+FeO

| | Hanging Wall Unaltered | Footwall Unaltered | Footwall Altered |
|---|---|---|---|
| $K_2O$ | 4.1 | 3.9 | 5.3 |
| $Na_2O$ | 3.2 | 3.1 | 2.0 |
| $K_2O/Na_2O$ | 1.05 | 1.25 | 2.65 |
| $Fe_2O_3$+FeO | 4.6 | 4.95 | 3.6 |

Table 1 clearly shows the increase in $K_2O$ and the decrease in $Na_2O$ and $Fe_2O_3$+FeO in the altered granite as compared to the unaltered series.

Attached ternary diagrams also illustrate the increase in $K_2O$ and the depletion of $Na_2O$ and $Fe_2O_3$+FeO in altered granite. In particular, Attachment 1 shows a substantial increase in $K_2O$ relative to iron and sodium abundances in altered granite. Furthermore, this increase in the $K_2O$ abundance is reflected in Attachment 2 as an increase in the normative orthoclase abundance in altered granite due to the additional potassium that can be allotted to the normative orthoclase phase.

## Discussion

Whole rock data makes it clear that the concentration of $K_2O$ has increased while the $Na_2O$ concentration has decreased in altered granite as compared to unaltered granite. Other observations and work done on the system that further substantiates these conclusions include:

1. Hand sample observations of K-spar associated with quartz veining; therefore, suggesting the introduction of potassium with the alteration solutions.

2. Thin section observations of: a) secondary K-spar (adularia) and b) sericite.

   a) The presence of secondary K-spar suggest alteration solutions rich in potassium.

   b) The presence of sericite suggests a loss of sodium. This is due to the intersticial sodium ions of plagioclase being remobilized during sericitization. The remobilization of the sodium is caused by the fact that sodium is not present within the alteration products crystal lattice (i.e. sericite); consequently, it is flushed through the system to be precipitated elsewhere.

3. XRD data on sericite indicates that the sericite is an alteration product of Na rich plagioclase (i.e. albite). Therefore, there is a large proportion of Na ions that are going to be incompatible with the newly formed alteration product, sericite; subsequently, the Na ions will be remobilized in the alteration solutions to be precipitated elsewhere.

Due to these lines of evidence, I conclude that there is definitely an introduction of $K_2O$ and a depletion of $Na_2O$ in the altered rocks.

With respect to the depletion of $Fe_2O_3$+FeO, I feel that this is due to the lack of whole rock data for the various mineralogical assemblages associated with alteration at Yarnell. The FeO & $Fe_2O_3$ minerals (i.e., mainly pyrite and limonite) are missing from the altered sample that was analyzed. However, pyrite and limonite are abundant in much of the altered granite. Therefore, it appears that ferrous and ferric iron are being concentrated in some areas, but depleted in others depending upon such variables as Eh, Ph, temperature, pressure and oxygen fugacity.

## Recommendations

It should be kept in mind when observing the data that the altered sample is only representative of the sericitized and silicified portion of the footwall and should not be misconstrued to represent the overall

composition of altered granite at Yarnell. Therefore, to further study the relationships of the alteration assemblages with regard to elemental abundances, I recommended doing a whole rock analysis from each characteristic alteration assemblage.

John J. Malusa

JJM:mek

cc: W.L. Kurtz

appendix A

Analysis in wt % HANG hangingwall granite unaltered

| SiO2 | TiO2 | Al2O3 | Fe2O3 | FeO | MnO | MgO | CaO | Na2O | K2O | P2O5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 70.00 | 0.70 | 14.30 | 3.20 | 1.40 | 0.11 | 1.00 | 2.60 | 3.20 | 4.10 | 0.45 | 101.06 |

CIPW Weight Norm

Q 29.90 or 24.23 ab 27.08 an 9.96 C 0.95 hy 2.49 mt 2.84
il 1.33 hem 1.24 ap 1.04

plag is An 27

Analysis in wt % FOOT footwall granite unaltered

| SiO2 | TiO2 | Al2O3 | Fe2O3 | FeO | MnO | MgO | CaO | Na2O | K2O | P2O5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 69.80 | 0.85 | 14.40 | 4.30 | 0.65 | 0.13 | 1.10 | 2.30 | 3.10 | 3.90 | 0.55 | 101.08 |

CIPW Weight Norm

Q 31.82 or 23.05 ab 26.23 an 7.82 C 2.21 hy 2.74 mt 0.06
il 1.61 hem 4.26 ap 1.27

plag is An 23

Analysis in wt %  GRNCORE  altered footwall

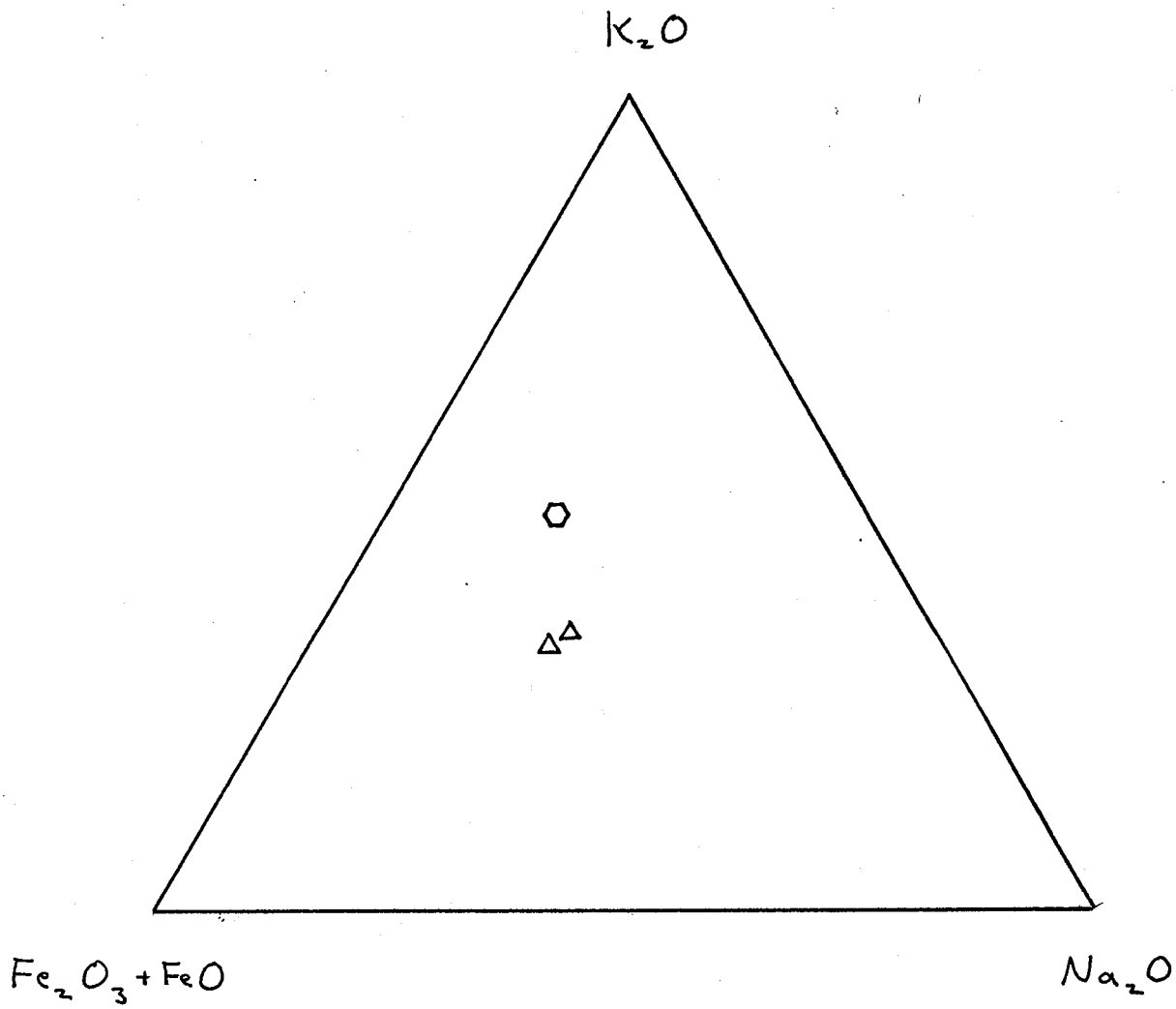
| SiO2 | TiO2 | Al2O3 | Fe2O3 | FeO | MnO | MgO | CaO | Na2O | K2O | P2O5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 68.30 | 0.02 | 14.30 | 3.50 | 0.10 | 0.01 | 0.70 | 2.60 | 2.00 | 5.30 | 0.10 | 96.93 |

CIPW Weight Norm

Q 30.05 or 31.32 ab 16.92 an 12.25 C 0.79 hy 1.74 mt 0.30
il 0.04 hem 3.30 ap 0.23

plag is An 42

Attch. 1



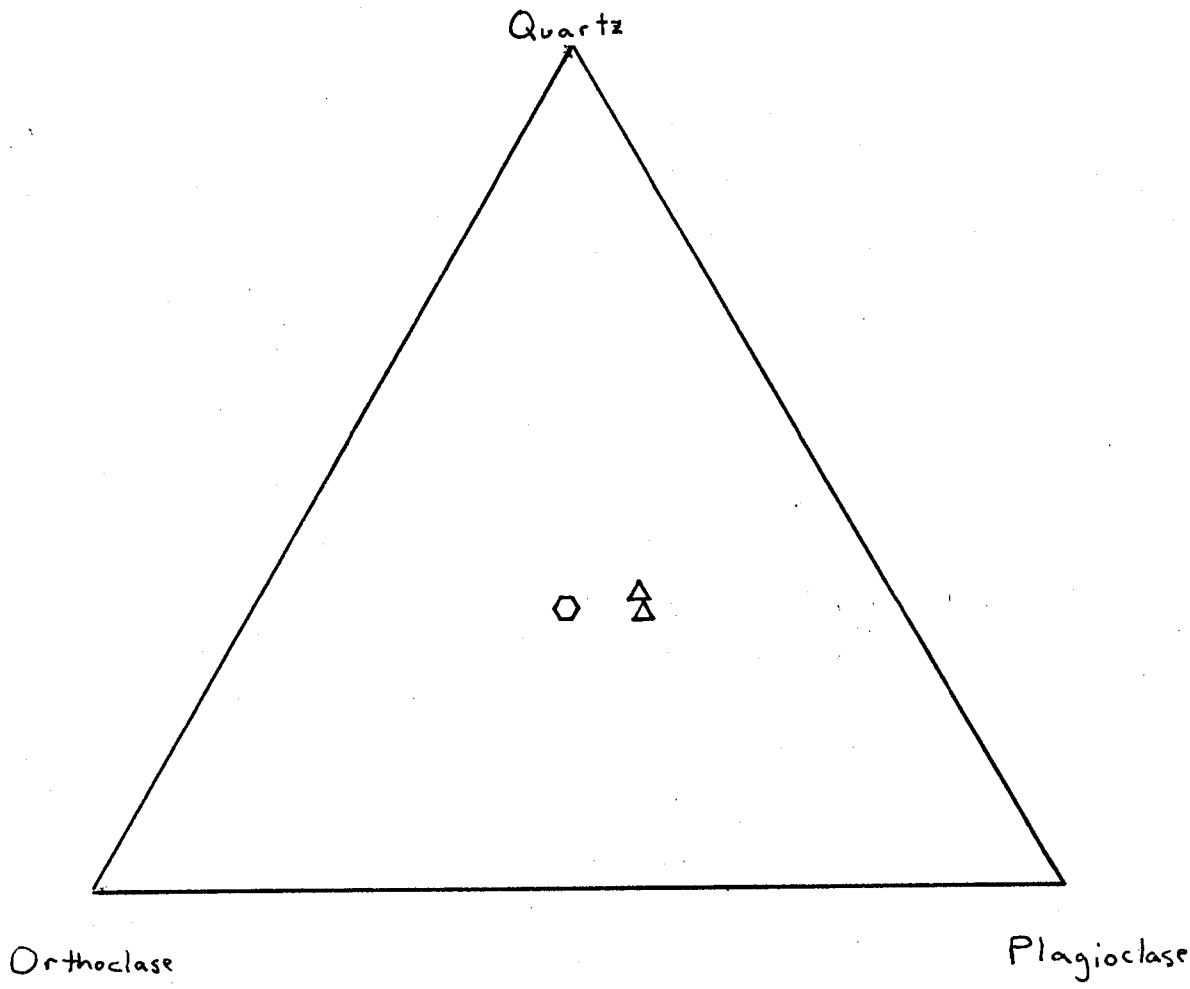

⬡ altered granite

△ unaltered granite

AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

Attch. 2

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD




⬡ altered granite

△ unaltered granite

ASARCO

Exploration Department
Western USA

July 23, 1990

R.L. Brown
New York Office

Yarnell Project
Termination?

As I have pointed out previously and as enumerated in the attached June 12, 1990 memo by S. L. Lakosky, Asarco must notify Norgold by September 1, 1990, if we are going to terminate and not be responsible for the $100,000 payment to Western Building and Mining.

You, we, Asarco should make that decision now. If terminate is the decision, we would then have 30 days to find a party to whom we could assign our interest and, hopefully, recoup our costs to date.

W. L. Kurtz

WLK:mek
Att.

cc: S.L. Lakosky
J.D. Sell

ASARCO

Southwestern Mining Department

June 12, 1990

RECEIVED

JUN 13 1990

EXPLORATION DEPARTMENT

MEMORANDUM

TO: T. E. Scartaccini

FROM: S. L. Lakosky

RE: Yarnell Project Exploration and Option Payments

Per the Asarco/Norgold Exploration and Option Agreement dated January 31, 1989, and subject to the right of Asarco to terminate said Agreement by providing Norgold 30 days advance notice of such termination, Asarco is obligated to make the following additional option payments on or before the Agreement expiration date of July 1, 1991:

| PAYEE | AMOUNT | 30 DAY ADVANCE NOTICE OF TERMINATION DEADLINE(Before) | PAYMENT DUE (On or Before) |
|---|---|---|---|
| Heintzelman | $ 5,000.00 | 5-30-90 | 6-30-90 |
| Norgold | 20,000.00 | 6-1-90 | 7-1-90 |
| Western Building and Mining Co. | 100,000.00 | 9-1-90* | 1-1-91 |
| Heintzelman | 12,500.00 | 11-30-90 | 12-31-90 |
| Norgold | 25,000.00 | 12-1-90 | 1-1-91 |
| Layton | 25,000.00 | 3-21-91 | 4-21-91 |
| Heintzelman | 12,500.00 | 5-30-91 | 6-30-91 |
| Norgold | 25,000.00 | 6-1-91 | 7-1-91 |
| Total | $225,000.00 | | |

* Even if Asarco provides Norgold with advance notification of termination of the Exploration and Option Agreement before 9-1-90,Asarco must also notify Norgold before 10-1-90 that Asarco doesn't intend to make the 1-1-91 payment to Western Building and Mining Co., otherwise, Asarco will still be obligated to make such payment.

S. L. Lakosky

S. L. Lakosky
Mine Superintendent
Mission Unit

SLL/kh
cc: RJKupsch
RLBrown
KRMorano
DECrowell
WLKurtz
JDSell
File

JDS → [illegible]

**ASARCO**

**MISSION UNIT**

To: T.E. Scartaccini, Gen. Mgr.
Southwest Dept. ASARCO

July 23, 1990

YARNELL PROJECT

Reclamation of the potential gold mining operation at the Yarnell Project site should be relatively easy to achieve. The site sits at an elevation of approximately 4500 ft. to 5000 ft. MSL. The site receives approximately 10-12 inches of precipitation per year and lies in a chaparral ecosystem. The soil materials are basically a decomposed granitic material. In fact if the mining operation becomes a reality the reclamation will offer an opportunity to "clean-up" existing mining disturbances from the past.

This reclamation "plan" is based on a very limited data and by no means should be construed as the "final plan". It is assumed that visual impacts are the most important aspects of reclamation. The plant species composition and reclamation work is aimed at producing a viable ecosystem that will not only blend in with the natural vegetation, but will also enhance wildlife values. The "Eonite" treatment of the pit walls is designed to "soften" the harsh starkness of the rock walls of the pit that are visible from the highway and the settlement of Glen Ilah.

Many things were "assumed" in this reclamation plan. It is assumed that soil materials for the capping of the waste dumps and heap leach are available on site. A cost of $5/cu.yd. is presummed adequate for excavation, transport, and application of the material based on Mission capping costs of approximately $2.60/cu.yd.. Actually the excavated "waste" overburden materials from the open pit may be satisfactory for revegetation without any "capping". Testing of the material for actual revegetation, however cannot be done until after mining has commenced. There is also the potential opportunity to utilize waste sludge materials from the nearby dairy facility that could prove to be more cost effective than "capping". As it is at this point it appears that the reclamation of this project may cost from $2,009,815 (avg. $20,940/ac.) to a high of $4,684,165 (avg. $48,795/ac.).

Stuart A. Bengson
Agronomist

cc:
J.D. Low
S.L. Laksosky
M. Miller

# YARNELL PROJECT RECLAMATION

## WASTE DUMPS:

Soil capping requirements based on recent capping of Mission tailings slopes - slopes of 1.5:1 - 50 ft. slope = avg. 4500 cu.yds./acre (3400-5125)

For longer slopes: 75 ft. est. 6750 cu.yd./acre
100 ft. est. 9000 cu.yd./acre
125 ft. est. 11,250 cu.yd./acre
150 ft. est. 13,500 cu.yd./acre
200 ft. est. 18,000 cu.yd./acre

SLOPES:
4700 el. approx. 2425 cu.yd. (.55 acres of slope)
4850 el. " 31,790 cu.yd. (2.95 acres of slope)
4900 el. " 15,300 cu.yd. (2.20 " )

4770 el. approx. 4795 cu.yd. (.85 acres of slope)
4820 el. " 8650 cu.yd. (1.15 " )
4870/4860 el. approx. 26,535 cu.yd. (4.30 acres of slope)

Capping the tops of the dumps to a depth of 6 inches

TOPS:
4700 el. approx. 1910 cu.yd. (2.40 acres)
4850 el. " 1185 cu.yd. (1.50 acres)
4900 el. " 5225 cu.yd. (6.50 acres)

4770 el. approx. 540 cu.yd. (.70 acres)
4820 el. " 1055 cu.yd. (1.30 acres)
4870/4860 el. approx. 10,595 cu.yd. (13.15 acres)

TOTAL DUMP CAPPING = 110,005 cu.yd. soil material

TOTAL DUMP ACRES = 37.55

TOTAL WASTE DUMP RECLAMATION (approx. 37.55 acres) =
110,005 cu.yd. @$5/cu.yd. = $550,025
@$10 " = $1,100,050
@$15 " = $1,650,075
hydroseeding and planting 37.55 ac. @$2750/acre = $103,265
irrigation system = $115,000

total $768,290 - $1,318,315 - $1,868,340

# YARNELL PROJECT RECLAMATION

## HEAP LEACH CAPPING:

W. Face = approx. 52,720 cu.yd.
S. Face = " 30,790 cu.yd.
E. Face = " 61,960 cu.yd.
Top = " 11,960 cu.yd.

TOTAL HEAP LEACH CAPPING = 157,430 cu.yd. soil material

Slope acres = approx. 32 acres
Top acres = " 14.5 acres

TOTAL HEAP LEACH ACRES = 46.5 acres

TOTAL HEAP LEACH RECLAMATION (approx. 46.5 acres) =
157,430 cu.yd. @$5/cu.yd. = $787,150
@$10 " = $1,574,300
@$15 " = $2,361,450
hydroseeding and planting 46.5 acres @$2750/acre = $127,875
irrigation system = $140,000

total $1,055,025 - $1,842,175 - $2,629,325

# YARNELL PROJECT RECLAMATION

## PIT WALLS:

The high point of the pit back wall = approx. 5118 el.
The low point of the pit front wall (facing the highway) = 4890 el.
(lowest viewpoint on highway = 4718 el.
- most of highway = 4800
highest viewpoint from Glen Ilah = 4880 el.)

difference = 228 ft. @20 ft. benches = approx. 12 benches

Spray "Eonite" (a man-made desert varnish) on the rock faces of the pit benches to oxidize the rock and form a natural appearing "patina" to blend in with the natural weathered rock of adjacent undisturbed sites.

Total slope face = approx. 15,000 linear ft.
@$.30/sq.ft. total cost = $157,500

plant trees & shrubs on the benches:
plant on 8 ft. centers - 2000 plants @$2 ea. plus labor
total = $9000

drip irrigation system & water line for temporary irrig.
total = $20,000

TOTAL PIT RECLAMATION (approx. 12 acres) = $186,500

# YARNELL PROJECT SPECIES

Potential Reveg Species:

cane bluestem - (Anba) @3#PLS
*plains bristlegrass - (Sema) @8#PLS
*black grama "Sonora" - (Boer) @2#PLS
blue grama - (Bogr) @3#PLS
sideoats grama - (Bocu) @5#PLS
weeping lovegrass - (Ercu) @5#PLS
*plains lovegrass - (Erin) @3#PLS
*Lehmans lovegrass - (Erle) @3#PLS
*Atherstone lovegrass - (Erat) @3#PLS
crested wheatgrass - (Agcr) @8#PLS
*thickspike wheatgrass - (Agda) @5#PLS
*bufflegrass - (Ceci) @8#PLS
blue panicgrass - (Paan) @5#PLS
*indian ricegrass - (Orhy) @8#PLS
*spike dropseed - (Spco) @2#PLS
*sand dropseed - (Spcr) @4#PLS
**mesa dropseed - (Spfl) @3#PLS
**giant dropseed - (Spgi) @3#PLS
alkali sacaton - (Spai) @3#PLS
prairie sandreed - (Calo) @5#PLS
*mammoth wildrye - (Elgi) @10#PLS
*Canby bluegrass - (Poca) @3#PLS
*2-flower trichatus - (Trcr) @8#PLS
*AZ cottontop - (Dica) @5#PLS
*needle & threadgrass - (Stco) @8#PLS
*"Zorro" fescue - (Feme) @8#PLS
*vine mesquite - (Paob) @8#PLS
*schizmus - (Scba) @2#PLS
alfileria - (Erci) @15#PLS
sweetclover - (Meal & Meof) @10#PLS
rose clover - (Trhi) @5#PLS
penstemmon parryi - (Pepa) @15#PLS

**catclaw - (Acgr)
**whitethorn - (Acco)
NM locust - (Rone) @75#PLS
**4-wing saltbush - (Atca) @15#PLS
quailbush - (Atle) @8#PLS
Nuthall's saltbush - (Atnu) @7#PLS
**ephedra - (Epvi) @50#PLS
CA buckwheat - (Erfa)
winterfat - (Eula) @15#PLS
twinberry - (Mesc) @20#PLS
big sage - (Artr) @1#PLS
false mesquite - (Caer)
buckbrush - (Cefe)
desert ceanothus - (Cegr)
mnt. mahogany - (Cele) @12#PLS
cliff rose - (Come) @20#PLS
**apache plume - (Fapa)

YARNELL SPECIES CONT'D:

ratany - (Krpa)
bitter brush - (Putr) @58#PLS
sumac - (Rhmi)
*skunkbrush - (Rhtr) @40#PLS
hopseed - (Dovi)
Russian olive - (Elan)
kochia - (Koam)

* indicates species especially well adapted to the Yarnell site.

# YARNELL PROJECT RECLAMATION

SEED MIX:

giant dropseed - 3#PLS @$7
sand dropseed - 4#PLS @$2
plains bristlegrass - 8PLS @$7
sideoats grama - 5PLS @$5
Atherstone lovegrass - 3PLS @$11
Lehmans lovegrass - 3PLS @$5
bufflegrass - 8PLS @$8
AZ cottontop - 5PLS @$25

WARM SEASON SEED MIX

$350/acre

indian ricegrass - 8PLS @$5
thickspike wheatgrass - 5PLS @$3
mammoth wildrye - 10PLS @$5
Canby bluegrass - 3PLS @$5
afileria - 15PLS @$25
sweetclover - 20PLS @$1
crested wheatgrass - 8PLS @$1
rose clover - 5PLS @$3
prairie sandreed - 5PLS @$12

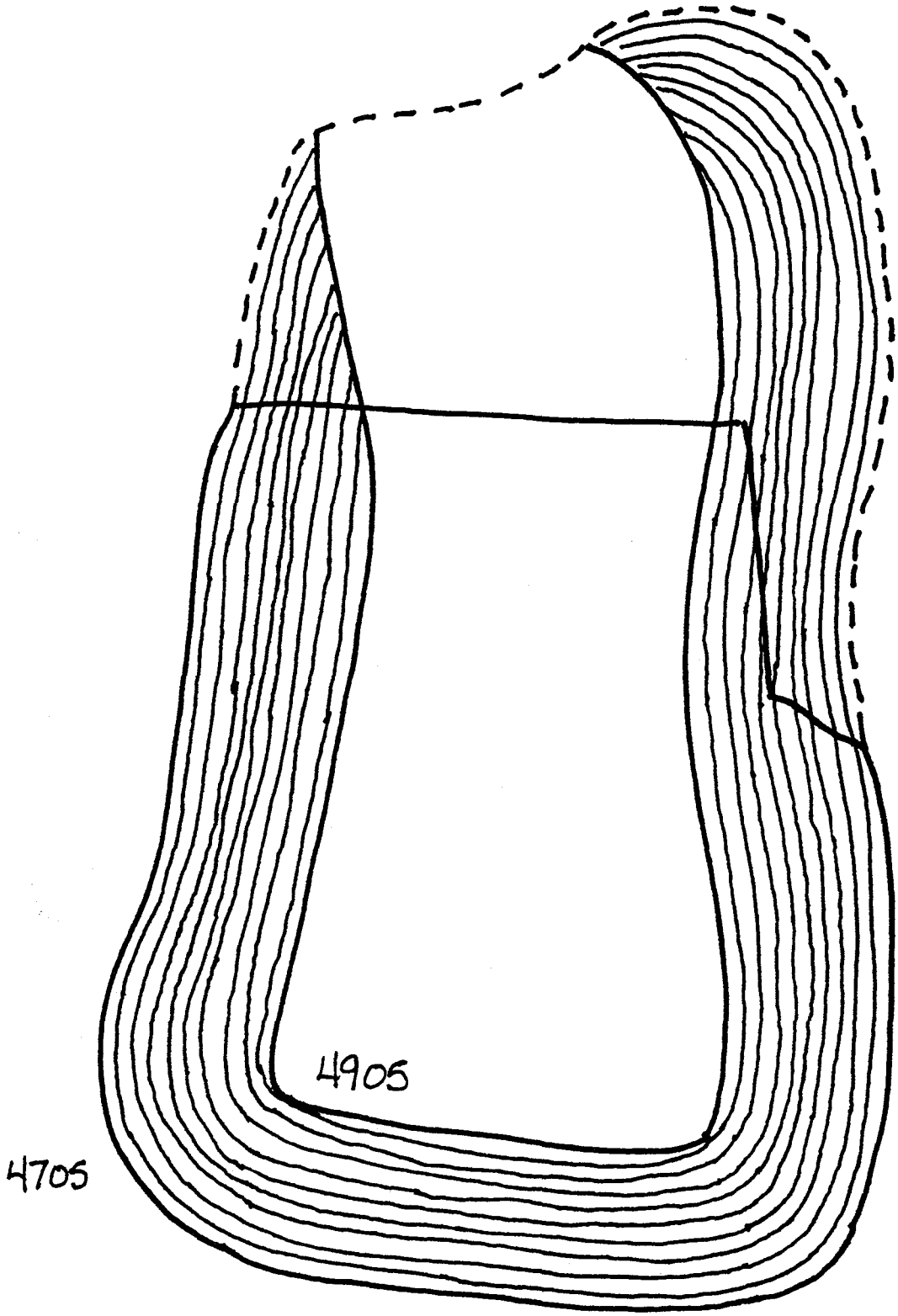
COOL SEASON SEED MIX

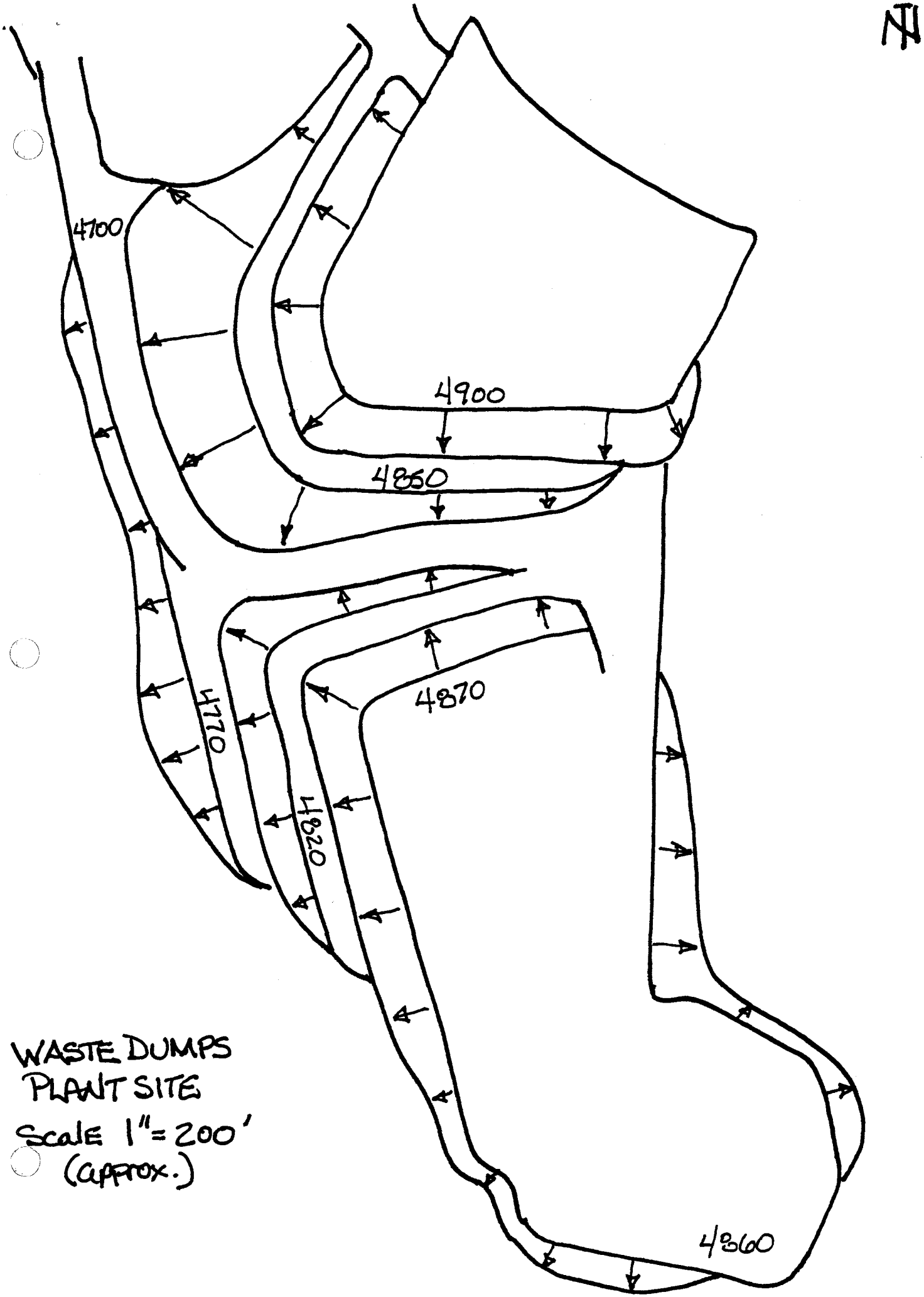
$600/acre

Planting trees & shrubs on 8-10 ft. centers = 680-435/acre
@$1.50-$2.25 ea. (avg. $1.88 ea.) = $1280-$820/acre

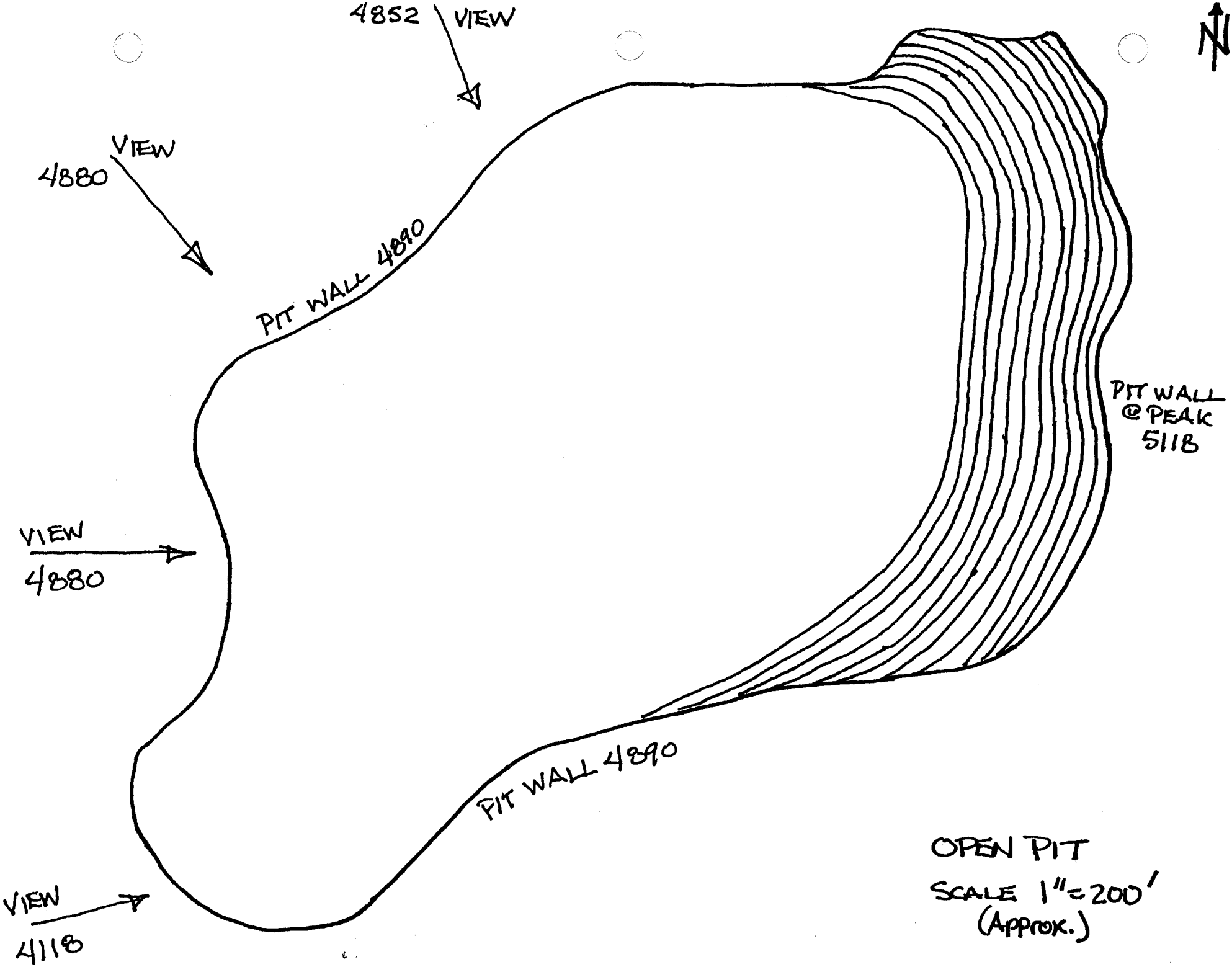
HEAP LEACH

SCALE 1" = 200'
(approx.)






WASTE DUMPS
PLANT SITE
Scale 1" = 200'
(approx.)


4852 VIEW
VIEW 4880
PIT WALL 4890
PIT WALL @ PEAK 5118
VIEW 4880
PIT WALL 4890
VIEW 4118
OPEN PIT
SCALE 1" = 200'
(APPROX.)

**ASARCO**

**Southwestern Exploration Division**

JDS

July 25, 1990

J.D. Sell

Carl Olsen Claims
Gold Rock 142, Gold Rock Mill Site
Yarnell Project, Yavapai Co., AZ

Carl Olsen's estate is now under the control of his sister, Brenda Flattery (602-427-6240), who is the executrix of his estate. This also includes the Gold Rock Group of claims along with the Gold Rock Mill Site. It is recommended that we offer her $5,000 for the claims; the purpose being to consolidate our outer perimeter land position. Incidentally, I found visible gold in quartz veins on the claims in the past.

Mark A. Miller

MAM:mek

cc: S.L. Lakosky

JAS

MIS-1.0

**ASARCO**

**MISSION UNIT**

July 25, 1990

MEMORANDUM

RECEIVED
JUL 25 1990
EXPLORATION DEPARTMENT

To: T. E. Scartaccini

From: S. L. Lakosky

Re: Yarnell Project

On July 23, 1990 ASARCO Incorporated's Agronomist Stuart A. Bengson completed reclamation cost estimates for the Yarnell Project.

The following tables list the DCFROI percentages for Asarco's portion of Norgold's various options, at gold prices from $350 to $450 per ounce. Reclamation costs have been estimated to range between $2,010,000 and $4,684,000, so separate tables have been prepared for each.

YARNELL PROJECT

DCFROI PERCENT WITH RECLAMATION COST AT $2,010,000

| GOLD PRICE $/OZ. | PROJECT 100% BASIS | ASARCO'S PORTION OF NORGOLD'S VARIOUS OPTIONS 51/49JV | NET PROFITS | MINING LEASE |
|---|---|---|---|---|
| 450 | 28.7 | 26.6 | 17.7 | 20.3 |
| 425 | 18.9 | 17.5 | 6.7 | 11.9 |
| 400 | 8.1 | 7.4 | (7.1) | 3.0 |
| 375 | (4.0) | (3.7) | * | (6.8) |
| 350 | (18.9) | (17.1) | * | * |

DCFROI PERCENT WITH RECLAMATION COST AT $4,684,000

| GOLD PRICE $/OZ. | PROJECT 100% BASIS | ASARCO'S PORTION OF NORGOLD'S VARIOUS OPTIONS 51/49JV | NET PROFITS | MINING LEASE |
|---|---|---|---|---|
| 450 | 24.6 | 22.7 | 1.2 | 16.4 |
| 425 | 13.5 | 12.4 | * | 6.8 |
| 400 | 0.2 | 0.1 | * | (4.4) |
| 375 | (20.7) | (17.3) | * | (20.6) |
| 350 | * | * | * | * |

* INDICATES RATES OF RETURN WHICH ARE TOO LOW TO BE CALCULATED BY LOTUS 123. ALL OF THESE RATES ARE LESS THAN (21%).

Attached are printouts of Norgold's various options at a gold price of $400 and a reclamation cost of $2,010,000. Section 1 defines the project on a 100% basis and also defines the 51/49 Joint Venture Option. Section 2 contains the 15% Net Profits Option and Section 3 contains the Mining Lease Option.

S. L. Lakosky

S. L. Lakosky
Mine Superintendent
Mission Unit

SLL/lb

Attachments

cc: RJKupsch, w/attachs.
RLBrown, w/attachs.
KRMorano, w/attachs.
DECrowell, w/attachs.
WLKurtz, w/attachs.
JDSell, w/attachs.

# S E C T I O N 1

EXPLORATIO[illegible]PITAL, AND DEVELOPMENT EXPENDITURES ($'000'S)

YARNELL

*$400 ECONOMIC PIT DESIGN*

| | 1989-1990 ASARCO | 1990 J/V | 1991 J/V | 1992 J/V | 1993 J/V | 1994 J/V | 1995 J/V | 1996 J/V | 1997 J/V | 1998 J/V | 1999 J/V | SUB-TOTAL 1989 - 1990 ASARCO | SUB-TOTAL 1990-1999 J/V | GRAND TOTAL 1989 - 1999 ASARCO & J/V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXPLORATION | | | | | | | | | | | | | | |
| OPTION AND LAND PAYMENTS | 217 | 82 | 137 | 150 | 210 | 100 | 0 | 0 | 0 | 0 | 0 | 217 | 679 | 896 |
| DRILLING, METALLURGICAL, MISC. | 807 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 807 | 0 | 807 |
| TOTAL | 1024 | 82 | 137 | 150 | 210 | 100 | 0 | 0 | 0 | 0 | 0 | 1024 | 679 | 1703 |
| CAPITAL AND DEVELOPMENT | | | | | | | | | | | | | | |
| PURCHASE (2) NEARBY HOMES | 0 | 400 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 400 | 400 |
| CONDEMNATION DRILLING | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| FINAL METALLURGICAL TESTING | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 50 |
| HYDROGEOLOGIC TESTING | 0 | 300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 300 | 300 |
| ENVIRONMENTAL ASSESSMENT | 0 | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | 200 |
| PERMITTING | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| MICROWAVE RELOCATIONS | 0 | 450 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 450 | 450 |
| WATER SUPPLY | 0 | 0 | 1000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 1000 |
| MONITOR WELL EQUIP. | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 50 |
| TRUCK SHOP FACILITY | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MINE/CRUSH CONTRACTOR MOB. | 0 | 0 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 150 | 150 |
| SITE PREP., SERVICES, DISTRIBUTION | 0 | 500 | 1085 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1585 | 1585 |
| PRIMARY CRUSHING FACILITY | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SECONDARY CRUSHING FACILITY | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CONVEYING/STACKING SYSTEM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ADSORPTION, DESORPTION, REFINING | 0 | 0 | 1440 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1440 | 1440 |
| HEAP PAD | 0 | 0 | 1061 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1061 | 1061 |
| PONDS AND SOLUTION DIST. | 0 | 0 | 558 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 558 | 558 |
| ANCILLARY FACILITIES & MOB. EQUIP. | 0 | 0 | 785 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 785 | 785 |
| CONSTRUCTION OVERHEAD & GEN. IND. | 0 | 489 | 490 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 979 | 979 |
| SUB-TOTAL | 0 | 2589 | 6619 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9208 | 9208 |
| CONTINGENCY @ 10% | 0 | 259 | 662 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 921 | 921 |
| TOTAL | 0 | 2848 | 7281 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10129 | 10129 |
| DELAYED/ONGOING CAPITAL EXPENDITURES | | | | | | | | | | | | | | |
| HEAP PAD EXPANSION | 0 | 0 | 0 | 0 | 1402 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1402 | 1402 |
| SOLUTION DIST. EXTENSION | 0 | 0 | 0 | 0 | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 29 |
| YARNELL CREEK ROAD RELOCATION | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CARBON REGENERATION KILN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SUB-TOTAL | 0 | 0 | 0 | 0 | 1431 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1431 | 1431 |
| CONTINGENCY @ 10% | 0 | 0 | 0 | 0 | 143 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 143 | 143 |
| TOTAL | 0 | 0 | 0 | 0 | 1574 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1574 | 1574 |
| MINE CLOSURE COSTS | | | | | | | | | | | | | | |
| MINE/CRUSH CONTRACTOR DEMOB. | 0 | 0 | 0 | 0 | 0 | 0 | 150 | 0 | 0 | 0 | 0 | 0 | 150 | 150 |
| HEAP & POND NEUTRALIZATION | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 50 | 50 |
| HEAP & DUMP CAPPING * | 0 | 0 | 0 | 0 | 0 | 0 | 2010 | 0 | 0 | 0 | 0 | 0 | 2010 | 2010 |
| PIT FENCING | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 20 | 20 |
| SUB-TOTAL | 0 | 0 | 0 | 0 | 0 | 0 | 2230 | 0 | 0 | 0 | 0 | 0 | 2230 | 2230 |
| CONTINGENCY @ 10% | 0 | 0 | 0 | 0 | 0 | 0 | 223 | 0 | 0 | 0 | 0 | 0 | 223 | 223 |
| TOTAL | 0 | 0 | 0 | 0 | 0 | 0 | 2453 | 0 | 0 | 0 | 0 | 0 | 2453 | 2453 |
| GRAND TOTAL | $1,024 | $2,930 | $7,418 | $150 | $1,784 | $100 | $2,453 | $0 | $0 | $0 | $0 | $1,024 | $14,835 | $15,859 |

* PER REVISION BY STUART BENGSON (ASARCO AGRONOMIST) ON 7/23/90.

YARNELL PROJECT

*$400 ECONOMIC PIT DESIGN*

72% RECOVERY

| $400 GOLD PRICE | 1989-1990 ASARCO | 1990 J/V | 1991 J/V | 1992 J/V | 1993 J/V | 1994 J/V | 1995 J/V | 1996 J/V | 1997 J/V | 1998 J/V | 1999 J/V | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MINING SCHEDULE | | | | | | | | | | | | |
| ORE TONS ('000'S) | 0 | 0 | 537 | 1071 | 1074 | 1072 | 174 | 0 | 0 | 0 | 0 | 3928 |
| WASTE TONS - INCL. PRE PROD ('000'S) | 0 | 0 | 1563 | 1914 | 1919 | 1353 | 0 | 0 | 0 | 0 | 0 | 6749 |
| STRIPPING RATIO | 0 | 0 | 2.91 | 1.79 | 1.79 | 1.26 | - | - | - | - | - | 1.72 |
| ORE GRADE (OPT) | 0 | 0 | 0.055 | 0.053 | 0.053 | 0.046 | 0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.049 |
| RECOVERABLE OUNCES | 0 | 0 | 17932 | 40912 | 40984 | 35663 | 4003 | 0 | 0 | 0 | 0 | 139494 |
| OPERATING OUTCOME | | | | | | | | | | | | |
| REVENUE ($'000'S) | 0 | 0 | 7101 | 16201 | 16230 | 14123 | 1585 | 0 | 0 | 0 | 0 | 55240 |
| COST ($'000'S) | 0 | 0 | 4981 | 10223 | 10245 | 9248 | 2233 | 0 | 0 | 0 | 0 | 36930 |
| OPERATING OUTCOME | 0 | 0 | $2,120 | $5,978 | $5,985 | $4,875 | ($648) | $0 | $0 | $0 | $0 | $18,310 |
| TAX BASIS - 100% | | | | | | | | | | | | |
| PRE-PROD. COSTS | 0 | 354 | 1768 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2122 |
| EXPL./DEV. EXP. (LAND) | 217 | 82 | 137 | 150 | 210 | 100 | 0 | 0 | 0 | 0 | 0 | 896 |
| EXPL./DEV. EXP. (OTHER) | 807 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 807 |
| EXPENSE (ONGOING & CLOSURE) | 0 | 0 | 0 | 0 | 1574 | 0 | 2453 | 609 | 291 | 0 | 0 | 4927 |
| CAPITAL EXPENDITURES | 0 | 2848 | 7281 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10129 |
| SALVAGE @ 15% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 713 | 0 | 0 | 0 | 713 |
| DEPRECIATION | 0 | 0 | 1447 | 2481 | 1772 | 1265 | 3164 | 0 | 0 | 0 | 0 | 10129 |
| NET BEFORE DEPL. | -1024 | -436 | -1232 | 3348 | 2429 | 3509 | -6265 | 104 | -291 | 0 | 0 | 141 |
| DEPL. | 0 | 0 | 0 | 1674 | 1215 | 1755 | 0 | 0 | 0 | 0 | 0 | 4643 |
| NET BEFORE TAX | -1024 | -436 | -1232 | 1674 | 1215 | 1755 | -6265 | 104 | -291 | 0 | 0 | -4502 |
| TAX @ 38% | -389 | -166 | -468 | 636 | 462 | 667 | -2381 | 39 | -111 | 0 | 0 | -1711 |
| NET AFTER TAX | -635 | -270 | -764 | 1038 | 753 | 1088 | -3884 | 64 | -180 | 0 | 0 | -2791 |
| NET AFTER TAX CASH FLOW | ($635) | ($3,118) | ($6,598) | $5,192 | $3,739 | $4,108 | ($720) | $64 | ($180) | $0 | $0 | $1,852 |
| NET AFTER TAX CASH FLOW (1990 COMBINED) | | ($3,753) | ($6,598) | $5,192 | $3,739 | $4,108 | ($720) | $64 | ($180) | $0 | $0 | $1,852 |

$400 ECONOMIC PIT DESIGN

| | |
|---|---|
| DCFROI % | 8.1 |
| NPV @ 0% | $1,852 |
| NPV @ 5% | $807 |
| NPV @ 10% | ($317) |
| NPV @ 15% | ($1,004) |

$400 GOLD PRICE

YARNELL PROJECT

$400 ECONOMIC PIT DESIGN

72% RECOVERY

| $400 GOLD PRICE | 1989-1990 ASARCO | 1990 J/V | 1991 J/V | 1992 J/V | 1993 J/V | 1994 J/V | 1995 J/V | 1996 J/V | 1997 J/V | 1998 J/V | 1999 J/V | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MINING SCHEDULE | | | | | | | | | | | | |
| ORE TONS ('000'S) | 0 | 0 | 537 | 1071 | 1074 | 1072 | 174 | 0 | 0 | 0 | 0 | 3928 |
| WASTE TONS - INCL. PRE PROD ('000'S) | 0 | 0 | 1563 | 1914 | 1919 | 1353 | 0 | 0 | 0 | 0 | 0 | 6749 |
| STRIPPING RATIO | 0 | 0 | 2.91 | 1.79 | 1.79 | 1.26 | - | - | - | - | - | 1.72 |
| ORE GRADE (OPT) | 0 | 0 | 0.055 | 0.053 | 0.053 | 0.046 | 0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.049 |
| RECOVERABLE OUNCES | 0 | 0 | 17932 | 40912 | 40984 | 35663 | 4003 | 0 | 0 | 0 | 0 | 139494 |
| OPERATING OUTCOME | | | | | | | | | | | | |
| REVENUE ($'000'S) | 0 | 0 | 7101 | 16201 | 16230 | 14123 | 1585 | 0 | 0 | 0 | 0 | 55240 |
| COST ($'000'S) | 0 | 0 | 4981 | 10223 | 10245 | 9248 | 2233 | 0 | 0 | 0 | 0 | 36930 |
| OPERATING OUTCOME | 0 | 0 | $2,120 | $5,978 | $5,985 | $4,875 | ($648) | $0 | $0 | $0 | $0 | $18,310 |
| TAX BASIS - ASARCO @ 51% OF J/V | | | | | | | | | | | | |
| PRE-PROD. COSTS | 0 | 354 | 1768 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2122 |
| EXPL./DEV. EXP. (LAND) | 217 | 82 | 137 | 150 | 210 | 100 | 0 | 0 | 0 | 0 | 0 | 896 |
| EXPL./DEV. EXP. (OTHER) | 807 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 807 |
| EXPENSE (ONGOING & CLOSURE) | 0 | 0 | 0 | 0 | 1574 | 0 | 2453 | 609 | 291 | 0 | 0 | 4927 |
| CAPITAL EXPENDITURES | 0 | 2848 | 7281 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10129 |
| SALVAGE @ 15% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 713 | 0 | 0 | 0 | 713 |
| DEPRECIATION | 0 | 0 | 1447 | 2481 | 1772 | 1265 | 3164 | 0 | 0 | 0 | 0 | 10129 |
| NET BEFORE DEPL. | -1024 | -436 | -1232 | 3348 | 2429 | 3509 | -6265 | 104 | -291 | 0 | 0 | 141 |
| DEPL. | 0 | 0 | 0 | 1674 | 1215 | 1755 | 0 | 0 | 0 | 0 | 0 | 4643 |
| NET BEFORE TAX | -1024 | -436 | -1232 | 1674 | 1215 | 1755 | -6265 | 104 | -291 | 0 | 0 | -4502 |
| TAX @ 38% | -389 | -166 | -468 | 636 | 462 | 667 | -2381 | 39 | -111 | 0 | 0 | -1711 |
| NET AFTER TAX | -635 | -270 | -764 | 1038 | 753 | 1088 | -3884 | 64 | -180 | 0 | 0 | -2791 |
| NET AFTER TAX CASH FLOW | -635 | -3118 | -6598 | 5192 | 3739 | 4108 | -720 | 64 | -180 | 0 | 0 | 1852 |
| ASARCO AT 51% | | -2225 | -3365 | 2648 | 1907 | 2095 | -367 | 33 | -92 | 0 | 0 | 633 |
| ADJUSTMENT FOR G&A | 0 | 6 | 48 | 68 | 68 | 67 | 30 | 10 | 5 | 0 | 0 | 302 |
| ADJUSTED AFTER TAX CASH FLOW @ 51% | $0 | ($2,219) | ($3,317) | $2,716 | $1,975 | $2,162 | ($337) | $43 | ($87) | $0 | $0 | $935 |

$400 ECONOMIC PIT DESIGN

| | |
|---|---|
| DCFROI % | 7.4 |
| NPV @ 0% | $935 |
| NPV @ 5% | $263 |
| NPV @ 10% | ($236) |
| NPV @ 15% | ($806) |

$400 GOLD PRICE

YARNELL PROJECT

$400 ECONOMIC PIT DESIGN

72% RECOVERY

| $400 GOLD PRICE | 1989-1990 ASARCO | 1990 J/V | 1991 J/V | 1992 J/V | 1993 J/V | 1994 J/V | 1995 J/V | 1996 J/V | 1997 J/V | 1998 J/V | 1999 J/V | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MINING SCHEDULE | | | | | | | | | | | | |
| ORE TONS ('000'S) | 0 | 0 | 537 | 1071 | 1074 | 1072 | 174 | 0 | 0 | 0 | 0 | 3928 |
| WASTE TONS - INCL. PRE PROD ('000'S) | 0 | 0 | 1563 | 1914 | 1919 | 1353 | 0 | 0 | 0 | 0 | 0 | 6749 |
| STRIPPING RATIO | 0 | 0 | 2.91 | 1.79 | 1.79 | 1.26 | - | - | - | - | - | 1.72 |
| ORE GRADE (OPT) | 0 | 0 | 0.055 | 0.053 | 0.053 | 0.046 | 0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.049 |
| RECOVERABLE OUNCES | 0 | 0 | 17932 | 40912 | 40984 | 35663 | 4003 | 0 | 0 | 0 | 0 | 139494 |
| OPERATING OUTCOME | | | | | | | | | | | | |
| REVENUE ($'000'S) | 0 | 0 | 7101 | 16201 | 16230 | 14123 | 1585 | 0 | 0 | 0 | 0 | 55240 |
| COST ($'000'S) | 0 | 0 | 4981 | 10223 | 10245 | 9248 | 2233 | 0 | 0 | 0 | 0 | 36930 |
| OPERATING OUTCOME | 0 | 0 | $2,120 | $5,978 | $5,985 | $4,875 | ($648) | $0 | $0 | $0 | $0 | $18,310 |

BOOK BASIS

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PROJECT @ 100% | | | | | | | | | | | | |
| PRE-PROD. COSTS | 0 | 354 | 1768 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2122 |
| EXPL./DEV. EXP. (LAND) | 217 | 82 | 137 | 150 | 210 | 100 | 0 | 0 | 0 | 0 | 0 | 896 |
| EXPL./DEV. EXP. (OTHER) | 807 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 807 |
| CAPITAL EXPENDITURES | 0 | 2848 | 7281 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10129 |
| ONGOING EXP. | 0 | 0 | 0 | 0 | 1574 | 0 | 0 | 0 | 0 | 0 | 0 | 1574 |
| CLOSURE EXP. | 0 | 0 | 0 | 0 | 0 | 0 | 2453 | 609 | 291 | 0 | 0 | 3353 |
| SALVAGE @ 15% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 713 | 0 | 0 | 0 | 713 |
| DEPL/DEPN (ASARCO) | 0 | 0 | 140 | 279 | 280 | 279 | 45 | 0 | 0 | 0 | 0 | 1024 |
| DEPRECIATION (J/V) | 0 | 0 | 1675 | 3340 | 3350 | 3343 | 543 | 0 | 0 | 0 | 0 | 12251 |
| DEPL (J/V) | 0 | 0 | 30 | 107 | 933 | 1018 | 165 | 0 | 0 | 0 | 0 | 2253 |
| DEPL/DEPN TOTAL (J/V) | 0 | 0 | 1705 | 3447 | 4283 | 4361 | 708 | 0 | 0 | 0 | 0 | 14504 |
| TOTAL PLANT OPER. COST | 0 | 0 | 6686 | 13670 | 14528 | 13609 | 2941 | 0 | 0 | 0 | 0 | 51434 |
| OPERATING P & L (100% BASIS) | $0 | $0 | $415 | $2,531 | $1,702 | $514 | ($3,809) | $104 | ($291) | $0 | $0 | $1,165 |
| COST PER OUNCE | | | $373 | $334 | $354 | $382 | $735 | - | - | - | - | $369 |
| ASARCO AT 51% OF J/V | | | | | | | | | | | | |
| TOTAL PLANT OPER. COST | 0 | 0 | 3550 | 7251 | 7689 | 7220 | 1545 | 0 | 0 | 0 | 0 | 27255 |
| OPERATING P & L (51% BASIS) | $0 | $0 | $72 | $1,012 | $588 | ($18) | ($1,988) | $53 | ($148) | $0 | $0 | ($430) |
| COST PER OUNCE | | | $388 | $348 | $368 | $397 | $757 | - | - | - | - | $383 |
| ADJUSTMENT FOR G&A | 0 | 10 | 77 | 109 | 109 | 109 | 49 | 17 | 8 | 0 | 0 | 487 |
| ADJUSTED OPERATING P & L | 0 | 10 | 149 | 1121 | 697 | 91 | -1939 | 69 | -141 | 0 | 0 | 57 |
| ASARCO AT 51% OF J/V, W/O SUNK COST | | | | | | | | | | | | |
| TOTAL PLANT OPER. COST | 0 | 0 | 3410 | 6972 | 7409 | 6941 | 1500 | 0 | 0 | 0 | 0 | 26231 |
| OPERATING P & L (51% BASIS) | $0 | $0 | $212 | $1,291 | $868 | $262 | ($1,942) | $53 | ($148) | $0 | $0 | $594 |
| COST PER OUNCE | | | $373 | $334 | $354 | $382 | $735 | - | - | - | - | $369 |

$400 PIT

SCHEDULE

| 1989-1990 ASARCO | 1990 J/V | 1991 J/V | 1992 J/V | 1993 J/V | 1994 J/V | 1995 J/V | 1996 J/V | 1997 J/V | 1998 J/V | 1999 J/V | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 537 | 1071 | 1074 | 1072 | 174 | 0 | 0 | 0 | 0 | 3928 |
| 0 | 0 | 219 | 150 | 1784 | 100 | 0 | 0 | 0 | 0 | 0 | 2253 |
| | | 30 | 60 | 60 | 60 | 10 | 0 | 0 | 0 | 0 | 219 |
| | | | 47 | 48 | 47 | 8 | 0 | 0 | 0 | 0 | 150 |
| | | | | 826 | 824 | 134 | 0 | 0 | 0 | 0 | 1784 |
| | | | | | 86 | 14 | 0 | 0 | 0 | 0 | 100 |
| TOTAL | | 30 | 107 | 933 | 1018 | 165 | 0 | 0 | 0 | 0 | 2253 |

# SECTION 2

**ASARCO WITH NORGOLD IN 15% NET PROFITS OPTION**

$400 ECONOMIC PIT DESIGN

72% RECOVERY — $400 GOLD PRICE

AFTER CONVERSION DATE PER AGREEMENT

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| **MINING SCHEDULE** — BOOK (100%) | | | | | | | | | | |
| ORE TONS ('000'S) | 537 | 1071 | 1074 | 1072 | 174 | 0 | 0 | 0 | 0 | 3928 |
| WASTE TONS - INCL PRE PROD ('000'S) | 1563 | 1914 | 1919 | 1353 | 0 | 0 | 0 | 0 | 0 | 6749 |
| STRIPPING RATIO | 2.91 | 1.79 | 1.79 | 1.26 | - | - | - | - | - | 1.72 |
| ORE GRADE (OPT) | 0.055 | 0.053 | 0.053 | 0.046 | 0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.049 |
| RECOVERABLE OUNCES | 17932 | 40912 | 40984 | 35863 | 4003 | 0 | 0 | 0 | 0 | 139494 |
| **OPERATING OUTCOME ($'000'S)** | | | | | | | | | | |
| GROSS SALES | 7101 | 16201 | 16230 | 14123 | 1585 | 0 | 0 | 0 | 0 | 55240 |
| OPERATING COST | 4981 | 10223 | 10245 | 9248 | 2233 | 0 | 0 | 0 | 0 | 36930 |
| G & A | 157 | 223 | 223 | 222 | 99 | 34 | 16 | 0 | 0 | 974 |
| OPERATING COST (LESS G&A) | 4824 | 10000 | 10022 | 9026 | 2134 | -34 | -16 | 0 | 0 | 35956 |
| ALLOWABLE DEPRECIATION | 0 | 0 | 729 | 727 | 118 | 0 | 0 | 0 | 0 | 1574 |
| CLOSURE COST | 0 | 0 | 0 | 0 | 2453 | 609 | 291 | 0 | 0 | 3353 |
| NET RETURNS | 2277 | 6201 | 5479 | 4369 | -3120 | -575 | -275 | 0 | 0 | 14357 |
| ASARCO RECOUP | 2277 | 6102 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8379 |
| NET PROFITS ($'000's) | 0 | 100 | 5479 | 4369 | -3120 | -575 | -275 | 0 | 0 | 5978 |
| 15% (NORGOLD) | 0 | 15 | 822 | 655 | -468 | -86 | -41 | 0 | 0 | 897 |
| 85% (ASARCO) | 0 | 85 | 4657 | 3714 | -2652 | -489 | -234 | 0 | 0 | 5081 |
| TOTAL ASARCO ($'000's) | 2277 | 6186 | 4657 | 3714 | -2652 | -489 | -234 | 0 | 0 | 13460 |
| SALVAGE @ 15% | 0 | 0 | 0 | 0 | 0 | 713 | 0 | 0 | 0 | 713 |
| PRE-MINE | 2122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2122 |
| CAPITAL EXP. | 6257 | 0 | 1574 | 0 | 0 | 0 | 0 | 0 | 0 | 7831 |

**BOOK BASIS (ASARCO)**

| | 1989-1990 ASARCO | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXPL./DEV./LAND EXPEND. | 217 | 82 | 597 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 896 |
| EXPL./DEV. EXP. | 807 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 807 |
| CAPITAL EXP. | 0 | 2848 | 1024 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3872 |
| SUB-TOTAL | 1024 | 2930 | 1621 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5575 |
| TOTAL D & D | | | 2123 | 4234 | 4246 | 4238 | 688 | 0 | 0 | 0 | 0 | 15528 |
| G & A COST | | | 157 | 223 | 223 | 222 | 99 | 34 | 16 | 0 | 0 | 974 |
| OPERATING P & L ($'000's) | | | ($3) | $1,729 | $188 | ($746) | ($3,439) | $190 | ($250) | $0 | $0 | ($2,330) |
| COST PER OZ. | | | $396 | $354 | $391 | $417 | $1,255 | - | - | - | - | $413 |
| **WITHOUT SUNK COSTS** | | | | | | | | | | | | |
| TOTAL D & D | | | 1983 | 3955 | 3966 | 3958 | 642 | 0 | 0 | 0 | 0 | 14504 |
| G & A COST | | | 157 | 223 | 223 | 222 | 99 | 34 | 16 | 0 | 0 | 974 |
| OPERATING P & L ($'000's) | | | $137 | $2,009 | $468 | ($466) | ($3,393) | $190 | ($250) | $0 | $0 | ($1,306) |
| COST PER OZ. | | | $388 | $347 | $385 | $409 | $1,244 | - | - | - | - | $405 |

**ASARCO WITH NORGOLD IN 15% NET PROFITS OPTION**

$400 ECONOMIC PIT DESIGN

72% RECOVERY — $400 GOLD PRICE

AFTER CONVERSION DATE PER AGREEMENT

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| **MINING SCHEDULE** — AFTER TAX CASH BASIS | | | | | | | | | | |
| ORE TONS ('000'S) | 537 | 1071 | 1074 | 1072 | 174 | 0 | 0 | 0 | 0 | 3928 |
| WASTE TONS - INCL PRE PROD ('000'S) | 1563 | 1914 | 1919 | 1353 | 0 | 0 | 0 | 0 | 0 | 6749 |
| STRIPPING RATIO | 2.91 | 1.79 | 1.79 | 1.26 | - | - | - | - | - | 1.72 |
| ORE GRADE (OPT) | 0.055 | 0.053 | 0.053 | 0.046 | 0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.049 |
| RECOVERABLE OUNCES | 17932 | 40912 | 40984 | 35663 | 4003 | 0 | 0 | 0 | 0 | 139494 |
| **OPERATING OUTCOME ($'000'S)** | | | | | | | | | | |
| GROSS SALES | 7101 | 16201 | 16230 | 14123 | 1585 | 0 | 0 | 0 | 0 | 55240 |
| OPERATING COST (W/O G&A) | 4824 | 10000 | 10022 | 9026 | 2134 | -34 | -16 | 0 | 0 | 35956 |
| ALLOWABLE DEPRECIATION | 0 | 0 | 729 | 727 | 118 | 0 | 0 | 0 | 0 | 1574 |
| CLOSURE COST | 0 | 0 | 0 | 0 | 2453 | 609 | 291 | 0 | 0 | 3353 |
| NET RETURNS | 2277 | 6201 | 5479 | 4369 | -3120 | -575 | -275 | 0 | 0 | 14357 |
| ASARCO RECOUP | 2277 | 6102 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8379 |
| NET PROFITS ($'000's) | 0 | 100 | 5479 | 4369 | -3120 | -575 | -275 | 0 | 0 | 5978 |
| 15% (NORGOLD) | 0 | 15 | 822 | 655 | -468 | -86 | -41 | 0 | 0 | 897 |
| 85% (ASARCO) | 0 | 85 | 4657 | 3714 | -2652 | -489 | -234 | 0 | 0 | 5081 |
| ALLOWABLE DEPR. CREDIT | 0 | 0 | 729 | 727 | 118 | 0 | 0 | 0 | 0 | 1574 |
| TOTAL ASARCO | 2277 | 6186 | 5386 | 4441 | -2534 | -489 | -234 | 0 | 0 | 15034 |

**AFTER TAX CASH BASIS - ASARCO**

| | 1989-1990 ASARCO | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G & A COST | 0 | 0 | 157 | 223 | 223 | 222 | 99 | 34 | 16 | 0 | 0 | 974 |
| PRE-PROD. COSTS | 0 | 354 | 1768 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2122 |
| EXPL./DEV. EXP. (LAND) | 217 | 82 | 137 | 150 | 210 | 100 | 0 | 0 | 0 | 0 | 0 | 896 |
| EXPL./DEV. EXP. (OTHER) | 807 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 807 |
| EXPENSE (ONGOING & OTHER) | 0 | 0 | 0 | 0 | 1574 | 0 | 2453 | 609 | 291 | 0 | 0 | 4927 |
| CAPITAL EXPENDITURES | 0 | 2848 | 7281 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10129 |
| SALVAGE @ 15% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 713 | 0 | 0 | 0 | 713 |
| DEPRECIATION | 0 | 0 | 1447 | 2481 | 1772 | 1265 | 3164 | 0 | 0 | 0 | 0 | 10129 |
| NET BEFORE DEPL. | -1024 | -436 | -1232 | 3333 | 1607 | 2854 | -8250 | -419 | -541 | 0 | 0 | -4108 |
| DEPL. | 0 | 0 | 0 | 1666 | 804 | 1427 | 0 | 0 | 0 | 0 | 0 | 3897 |
| NET BEFORE TAX | -1024 | -436 | -1232 | 1666 | 804 | 1427 | -8250 | -419 | -541 | 0 | 0 | -8005 |
| TAX @ 38% | -389 | -166 | -468 | 633 | 305 | 542 | -3135 | -159 | -205 | 0 | 0 | -3042 |
| NET AFTER TAX | -635 | -270 | -764 | 1033 | 498 | 885 | -5115 | -260 | -335 | 0 | 0 | -4963 |
| NET AFTER TAX CASH FLOW | -635 | -3118 | -6598 | 5180 | 3073 | 3577 | -1951 | -260 | -335 | 0 | 0 | -1066 |
| NET AFTER TAX CASH FLOW (1990 COMBINED) | | ($3,753) | ($6,598) | $5,180 | $3,073 | $3,577 | ($1,951) | ($260) | ($335) | $0 | $0 | ($1,066) |

ASARCO WITH NORGOLD IN 15% NET PROFITS OPTION

| $400 ECONOMIC PIT DESIGN | |
|---|---|
| DCFROI % | -7.1 |
| NPV @ 0% | ($1,066) |
| NPV @ 5% | ($1,620) |
| NPV @ 10% | ($2,043) |
| NPV @ 15% | ($2,361) |

$400 GOLD PRICE

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NET AFTER TAX CASH FLOW W/O SUNK COSTS | ($3,118) | ($6,598) | $5,180 | $3,073 | $3,577 | ($1,951) | ($260) | ($335) | $0 | $0 | ($431) |

| $400 ECONOMIC PIT DESIGN | |
|---|---|
| DCFROI % | -3.0 |
| NPV @ 0% | ($431) |
| NPV @ 5% | ($1,016) |
| NPV @ 10% | ($1,466) |
| NPV @ 15% | ($1,809) |

$400 GOLD PRICE

# S E C T I O N 3

ASARCO WITH NORGOLD IN MINING LEASE OPTION

$400 ECONOMIC PIT DESIGN

72% RECOVERY — $400 GOLD PRICE

AFTER CONVERSION DATE PER AGREEMENT

AFTER TAX CASH BASIS

| MINING SCHEDULE | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| ORE TONS ('000'S) | 537 | 1071 | 1074 | 1072 | 174 | 0 | 0 | 0 | 0 | 3928 |
| WASTE TONS – INCL PRE PROD ('000'S) | 1563 | 1914 | 1919 | 1353 | 0 | 0 | 0 | 0 | 0 | 6749 |
| STRIPPING RATIO | 2.91 | 1.79 | 1.79 | 1.26 | – | – | – | – | – | 1.72 |
| ORE GRADE (OPT) | 0.055 | 0.053 | 0.053 | 0.046 | 0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.049 |
| RECOVERABLE OUNCES | 17932 | 40912 | 40984 | 35663 | 4003 | 0 | 0 | 0 | 0 | 139494 |
| **OPERATING OUTCOME ($'000'S)** | | | | | | | | | | |
| GROSS SALES | 7101 | 16201 | 16230 | 14123 | 1585 | 0 | 0 | 0 | 0 | 55240 |
| OPERATING COST (W/O G&A) | 4824 | 10000 | 10022 | 9026 | 2134 | -34 | -16 | 0 | 0 | 35956 |
| ALLOWABLE DEPRECIATION | 0 | 0 | 729 | 727 | 118 | 0 | 0 | 0 | 0 | 1574 |
| CLOSURE COST | 0 | 0 | 0 | 0 | 2453 | 609 | 291 | 0 | 0 | 3353 |
| NET PROFITS (BEFORE ASARCO PAYBACK) | 2277 | 6201 | 5479 | 4369 | -3120 | -575 | -275 | 0 | 0 | 14357 |
| ASARCO PAYBACK FROM 95% OF NET PROFITS | 2163 | 5891 | 5205 | 858 | 0 | 0 | 0 | 0 | 0 | 14117 |
| NET PROFITS (AFTER ASARCO PAYBACK & NORGOLD ROYALTY) | 0 | 0 | 0 | 3466 | -3120 | -575 | -275 | 0 | 0 | -504 |
| NORGOLD ROYALTY FROM 5% OF NET PROFITS | 114 | 310 | 274 | 45 | 0 | 0 | 0 | 0 | 0 | 743 |
| ASARCO @ 75% OF NET PROFITS AFTER PAYBACK | 0 | 0 | 0 | 2600 | -2340 | -431 | -206 | 0 | 0 | -378 |
| ALLOWABLE DEPR. CREDIT | 0 | 0 | 729 | 727 | 118 | 0 | 0 | 0 | 0 | 1574 |
| TOTAL ASARCO ($'000'S) | 2163 | 5891 | 5934 | 4185 | -2222 | -431 | -206 | 0 | 0 | 15314 |

AFTER TAX CASH BASIS – ASARCO

| | 1989-1990 ASARCO | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G & A COST | 0 | 0 | 157 | 223 | 223 | 222 | 99 | 34 | 16 | 0 | 0 | 974 |
| PRE-PROD COSTS | 0 | 354 | 1768 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2122 |
| EXPL./DEV. EXP. (LAND) | 217 | 82 | 137 | 150 | 210 | 100 | 0 | 0 | 0 | 0 | 0 | 696 |
| EXPL./DEV. EXP. (OTHER) | 807 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 807 |
| EXPENSE (ONGOING & OTHER) | 0 | 0 | 0 | 0 | 1574 | 0 | 2453 | 609 | 291 | 0 | 0 | 4927 |
| CAPITAL EXPENDITURES | 0 | 2848 | 7281 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10129 |
| SALVAGE @ 15% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 713 | 0 | 0 | 0 | 713 |
| DEPRECIATION | 0 | 0 | 1447 | 2481 | 1772 | 1265 | 3164 | 0 | 0 | 0 | 0 | 10129 |
| NET BEFORE DEPL. | -1024 | -436 | -1346 | 3038 | 2155 | 2598 | -5485 | -362 | -513 | 0 | 0 | -1376 |
| DEPL. | 0 | 0 | 0 | 1519 | 1078 | 1299 | 0 | 0 | 0 | 0 | 0 | 3895 |
| NET BEFORE TAX | -1024 | -436 | -1346 | 1519 | 1078 | 1299 | -5485 | -362 | -513 | 0 | 0 | -5271 |
| TAX @ 38% | -389 | -166 | -512 | 577 | 409 | 494 | -2084 | -137 | -195 | 0 | 0 | -2003 |
| NET AFTER TAX | -635 | -270 | -835 | 942 | 668 | 805 | -3401 | -224 | -318 | 0 | 0 | -3268 |
| NET AFTER TAX CASH FLOW | -635 | -3118 | -6668 | 4941 | 3517 | 3369 | -237 | -224 | -318 | 0 | 0 | 627 |
| NET AFTER TAX CASH FLOW (1990 COMBINED) | | ($3,753) | ($6,668) | $4,941 | $3,517 | $3,369 | ($237) | ($224) | ($318) | $0 | $0 | $627 |

**ASARCO WITH NORGOLD IN MINING LEASE OPTION**

$400 ECONOMIC PIT DESIGN

72% RECOVERY — $400 GOLD PRICE

AFTER CONVERSION DATE PER AGREEMENT

| MINING SCHEDULE — BOOK (100%) | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| ORE TONS ('000'S) | 537 | 1071 | 1074 | 1072 | 174 | 0 | 0 | 0 | 0 | 3928 |
| WASTE TONS - INCL PRE PROD ('000'S) | 1563 | 1914 | 1919 | 1353 | 0 | 0 | 0 | 0 | 0 | 6749 |
| STRIPPING RATIO | 2.91 | 1.79 | 1.79 | 1.26 | - | - | - | - | - | 1.72 |
| ORE GRADE (OPT) | 0.055 | 0.053 | 0.053 | 0.046 | 0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.049 |
| RECOVERABLE OUNCES | 17932 | 40912 | 40984 | 35663 | 4003 | 0 | 0 | 0 | 0 | 139494 |
| **OPERATING OUTCOME ($'000'S)** | | | | | | | | | | |
| GROSS SALES | 7101 | 16201 | 16230 | 14123 | 1585 | 0 | 0 | 0 | 0 | 55240 |
| OPERATING COST | 4981 | 10223 | 10245 | 9248 | 2233 | 0 | 0 | 0 | 0 | 36930 |
| G & A | 157 | 223 | 223 | 222 | 99 | 34 | 16 | 0 | 0 | 974 |
| OPERATING COST (LESS G&A) | 4824 | 10000 | 10022 | 9026 | 2134 | -34 | -16 | 0 | 0 | 35956 |
| ALLOWABLE DEPRECIATION | 0 | 0 | 729 | 727 | 118 | 0 | 0 | 0 | 0 | 1574 |
| CLOSURE COST | 0 | 0 | 0 | 0 | 2453 | 609 | 291 | 0 | 0 | 3353 |
| NET PROFITS (BEFORE ASARCO PAYBACK) | 2277 | 6201 | 5479 | 4369 | -3120 | -575 | -275 | 0 | 0 | 14357 |
| NET PROFITS (AFTER ASARCO PAYBACK & NORGOLD ROYALTY) | 0 | 0 | 0 | 3466 | -3120 | -575 | -275 | 0 | 0 | -504 |
| NORGOLD ROYALTY FROM 5% OF NET PROFITS | 114 | 310 | 274 | 45 | 0 | 0 | 0 | 0 | 0 | 743 |
| ASARCO PAYBACK FROM 95% OF NET PROFITS | 2163 | 5891 | 5205 | 858 | 0 | 0 | 0 | 0 | 0 | 14117 |
| ASARCO @ 75% OF NET PROFITS AFTER PAYBACK | 0 | 0 | 0 | 2600 | -2340 | -431 | -206 | 0 | 0 | -378 |
| TOTAL ASARCO ($'000's) | 2163 | 5891 | 5205 | 3458 | -2340 | -431 | -206 | 0 | 0 | 13739 |
| SALVAGE @ 15% | 0 | 0 | 0 | 0 | 0 | 713 | 0 | 0 | 0 | 713 |
| PRE-MINE | 2122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2122 |
| CAPITAL EXP. | 6257 | 0 | 1574 | 0 | 0 | 0 | 0 | 0 | 0 | 7831 |

**BOOK BASIS (ASARCO)**

| | 1989-1990 ASARCO | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 1989-1999 TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXPL./DEV./LAND EXPEND. | 217 | 82 | 597 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 896 |
| EXPL./DEV. EXP. | 807 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 807 |
| CAPITAL EXP. | 0 | 2848 | 1024 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3872 |
| SUB-TOTAL | 1024 | 2930 | 1621 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5575 |
| TOTAL D & D | | | 2123 | 4234 | 4246 | 4238 | 688 | 0 | 0 | 0 | 0 | 15528 |
| G & A COST | | | 157 | 223 | 223 | 222 | 99 | 34 | 16 | 0 | 0 | 974 |
| OPERATING P & L ($'000's) | | | ($117) | $1,434 | $736 | ($1,002) | ($3,127) | $247 | ($222) | $0 | $0 | ($2,050) |
| COST PER OZ. | | | $403 | $361 | $378 | $424 | $1,177 | - | - | - | - | $411 |
| **WITHOUT SUNK COSTS** | | | | | | | | | | | | |
| TOTAL D & D | | | 1983 | 3955 | 3966 | 3958 | 642 | 0 | 0 | 0 | 0 | 14504 |
| G & A COST | | | 157 | 223 | 223 | 222 | 99 | 34 | 16 | 0 | 0 | 974 |
| OPERATING P & L ($'000's) | | | $23 | $1,713 | $1,016 | ($723) | ($3,081) | $247 | ($222) | $0 | $0 | ($1,026) |
| COST PER OZ. | | | $395 | $354 | $371 | $416 | $1,166 | - | - | - | - | $403 |

ASARCO WITH NORGOLD IN MINING LEASE OPTION

| $400 ECONOMIC PIT DESIGN | |
|---|---|
| DCFROI % | 3.0 |
| NPV @ 0% | $627 |
| NPV @ 5% | ($372) |
| NPV @ 10% | ($1,113) |
| NPV @ 15% | ($1,661) |

$400 GOLD PRICE

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NET AFTER TAX CASH FLOW W/O SUNK COSTS | ($3,116) | ($8,668) | $4,941 | $3,517 | $3,369 | ($237) | ($224) | ($318) | $0 | $0 | $1,262 |

| $400 ECONOMIC PIT DESIGN | |
|---|---|
| DCFROI % | 6.4 |
| NPV @ 0% | $1,262 |
| NPV @ 5% | $233 |
| NPV @ 10% | ($536) |
| NPV @ 15% | ($1,109) |

$400 GOLD PRICE

# ASARCO

**Exploration Department**
Southwestern United States Division

CERTIFIED MAIL
RETURN RECEIPT

July 26, 1990

Mr. Les Rosenkrance, State Director
U.S. Department of the Interior
Bureau of Land Management
P.O. Box 16563
Phoenix, AZ 85011

Dear Sir:

Enclosed is Application for Survey of Mining Claim and the documents requested in the instructions. Also enclosed is a copy of special power of attorney for the individual signing for the applicant.

As processor of this application, ASARCO Incorporated, please send all correspondence to:

W.D. Gay, Land Engineer
ASARCO Incorporated
P.O. Box 5747
Tucson, AZ 85703

Telephone: (602) 792-3010

Very truly yours,

W. D. Gay
W.D. Gay
Land Engineer

WDG:mek
Encs.

cc: W.L. Kurtz
J.D. Sell
M.A. Miller

ASARCO

Southwestern Exploration Division

July 26, 1990

S.L. Lakosky, Jr.

Yarnell Project
Pennsylvania No. 1
Meeting with BLM Personnel
to discuss patent process.

On July 25, at 9:00 AM, J.D. Sell, M.A. Miller and I met with Bob Fisk, Mining Engineer, and Clyde Murray, Geologist, both with the BLM, to discuss in general the patenting of the Pennsylvania No. 1.

Started the meeting by telling the BLM people what we were showing and telling them was confidential, which they agreed to.

The meeting was very general, with Clyde Murray doing most of the talking. The three most important points were:

1. In application show what percent of total ore is on the Pennsylvania No. 1.

2. Show total data of mine plan, i.e., tons, grade, DCFROI, etc.

3. Application must include sufficient details for the Federal mine examiner to determine, in the office, whether a valuable mineral deposit has been found.

W. D. Gay

WDG:mek

W.D. Gay

cc: W.L. Kurtz
J.D. Sell
M.A. Miller

XGroxton — JDS — MOM

SKYLINE LABS, INC.
SPECIALISTS IN EXPLORATION GEOCHEMISTRY
12090 WEST 50TH PLACE • WHEAT RIDGE, COLORADO 80033 • TEL.: (303) 424-7718

July 27, 1990

Mr. Mark Miller
ASARCO, INC.
P.O. Box 5747
Tucson, Arizona 85703

ASARCO Incorporated
JUL 30 1990
SW Exploration

Dear Mark:

Charles Thompson of our Tucson office has requested that I send you the enclosed copy of Rick Schwarz's paper on minimizing errors in drill sampling for gold.

Rick followed this paper with a shorter one in the Association of Exploration Geochemists newsletter EXPLORE. A copy of this second article also is enclosed.

Rick has taken a couple of short courses in sampling and sample prep for gold that I also attended -- one by Francis Pitard of Broomfield, Colorado (formerly with AMAX and now a sampling consultant) and the other by Professor Allan Royles of the University of Leeds, England. The course manuals for both of these are, I'm sure, in the library at the University of Nevada in Reno. These two gentlemen convinced me of the importance of sample prep prior to sampling for gold -- hence the blurb on sampling error that Skyline recently distributed.

We don't profess to be masters of the statistical treatment of sampling and assay data, but we'll sure try to produce representative pulps!

Best wishes...

Sincerely,
SKYLINE LABS, INC.

Ed Post

Edwin V. Post
President

EVP/hs

# Chapter 4

## MINIMIZING ERRORS IN DRILL SAMPLING FOR GOLD

by

Frederick P. Schwarz
Senior Supervisory Geologist

Freeport-McMoRan Gold Company
Elko, Nevada

Abstract: Sample preparation and analysis can impose devastating errors on assay data. Minimizing these errors by testing and procedural redesign may be critical to assure representative assays and project success. Replicate samples, taken at any volume-reduction and/or analytical step in a sampling procedure, generate replicate assay values whose relative differences constitute a set of data. Variance of this data judges the addition to total sampling error imposed by the step generating the replicates. A variance more than $(11.5\%)^2$ is excessive for a single step. Sample volume increase and/or comminution at a step will reduce variance for that step. Rejects from well mineralized intercepts can provide bulk samples for testing.

### EFFECT OF ERROR

Sampling procedures introduce errors into the reliability of an assay value at every step in sample preparation and analysis. These cumulative errors cannot be totally eliminated, but they can be controlled. Control of error is critical to a project since less error in data generates more reliability in a resource estimate based on that data.

Sample splitting steps generally impose the worst procedural errors. The most serious splitting errors are commonly generated at the drillsite. Analytical procedures can also impose significant errors. Errors not from splitting or analytical steps are usually trivial... unless processing is carelessly done.

A single sampling procedural step can generate so much error, especially in gold exploration, that a reported assay value does not reflect true assay value for the sample. Such error is excessive. Excessive error can unmeasurably modify a given sample so that, notwithstanding the effect on the sample of any subsequent subsampling, assaying, and/or extrapolation, the sample and its assay are ineradicably non-representative.

Non-representative data which results from excessive error is characterized by an assay value distribution dependent only on sample inhomogeneity. This distribution is in effect superimposed on the true distribution of assay values. Combined true and superimposed distributions can not be characterized reliably by classical statistics. In extreme cases, geostatistics may not help.

A common type of superimposed assay value distribution in gold deposits causes most assay values to report lower than true, and a very few to report much higher than true. Thus, deposit grade above cutoff tends to be underestimated.

Assays from a non-representative data set are individually meaningless. Since these assays can indicate fluctuations of grade which are not real, reasonably accurate zoning of the deposit by grade may be impossible. Thus, with excessive error, the true assay distribution and a reasonable characterization of the orebody might never be known.

### MINIMIZING ERROR

For a single step of a sampling procedure, a practical limit for excessive error is considered to be when that step generates a data set of relative assay differences whose variance (the conventional statistic) exceeds $(11.5\%)^2$. With this limit in mind, the explorationist can test, judge, and minimize error.

A careful examination of sampling procedure is desirable early in the drilling stage of property evaluation. Such examination will reveal those procedural steps which may cause unacceptable error and, therefore, problems in assay reliability. These steps can be redesigned so that error is minimized. Minimizing



Reproduced by permission, SME of AIME

error will improve accuracy of project evaluation work, including: geologic conclusions, grade estimates, economic studies, and, eventually, mine planning.

## ESTIMATING ERROR USING VARIANCE OF REPLICATE ASSAYS

Assays of replicate samples isolated at any sample processing or analytical step can provide a data set comprised of relative differences between replicate sample assay values. Variance of this data set can be used to judge the magnitude of error which is generated by the step. Replicates from sample splitting of ore-grade mineralization usually are most useful for testing, since volume-reduction steps commonly generate highest variances.

The population of relative differences between replicate assays is a data set which shows a normal (Gaussian) distribution of values. A data population of actual assay values usually does not show a normal distribution. Thus, estimating error by use of the variance of a population of relative differences avoids many problems associated with the statistics of non-normal distributions.

The relative difference between assay values is shown by the relationship:

$$\% \text{ difference} = 100 \frac{(O-R)}{(O+R)} \qquad (1)$$

for original (O) and replicate (R) assay values. Thus, variance of a population of relative differences is expressed in units of percentage-squared (or $(\%)^2$).

## TESTING AN ESTABLISHED PROCEDURE

### Goals and General Approach

A drillhole sampling procedure is tested to discover if any processing step generates an excessive variance (more than $(11.5\%)^2$ for replicate assays), so that the step can be modified. Also, if variance of a step is substantially less than $(11.5\%)^2$, the procedure might be redesigned to reduce processing cost.

Once a sampling procedure has been optimized, reliability of data from later drilling is insured, and earlier samples from critical intervals, reprocessed and reassayed, become more useful. Thus, all the drillholes will provide reasonably representative assay data. The practical goal of testing an established procedure is to assure that reasonably representative assay data is generated routinely at reasonably minimized cost.

In the beginning stages of a drill evaluation program, samples for testing come from bulk reject drillhole cuttings. Assay values from these cuttings have confirmed interest in the project by returning "ore-grade" intercepts. Considering the value at risk in decisions which depend on reliable assay values, temporarily saving all bulk rejects from exploration drilling can be justified.

### Example Procedure

For the first few holes in a drilling program, sampling procedure is typically based on convenient logistics, standard laboratory procedures, company tradition, etc.. After substantial and continuing interest is confirmed, initially expedient procedure should be validated.

Figure 1 shows an example procedure which begins with 56 kg of sample, the material from a typical 5 ft run of rotary reverse circulation drilling. The sample is split 50-50 on each pass through riffle splitters, and reject material is set aside. Retained material is comminuted at various stages. Finally, a pulp provides the analytical sample.

Figure 2 illustrates a test of the sampling procedure from Figure 1. Reject drill cuttings, saved from the original process, supply replicate samples at several splitting steps as follow:

[A] at 50 kg of cuttings;

[B] at 12.5 kg of cuttings;

[C] at 3120 g of -10 mesh material;

[D] at 780 g of -80 mesh material;

[E] at 32 g (or 1 assay ton (AT)) of -200 mesh pulp.

In practice, every sample splitting step of the established procedure could be similarly tested. At a minimum, several 50 kg samples should be tested.

Samples from each pair of procedurally equivalent "branches" in Figure 2 are treated independently. It is important to carefully document sample lineage, thus allowing comparisons of appropriate replicate assays. Assays resulting from testing the procedure are as follows:

a) The 50 kg of material is split, at [A], into a pair of replicate samples leading to assay #1 along one branch and assays #2, #3, #4, #5, and #6 along other, procedurally equivalent branches.

b) The 12.5 kg of material is split similarly, at [B], leading to assay #2 along one branch and assays #3, #4, #5, and #6 along others.

c) The 3.12 kg of material is split similarly, at [C], leading to assay #3 along one branch and assays #4, #5, and #6 along others.

d) The 780 g of material is split similarly, at [D], leading to assay #4 along one branch and assays #5 and #6 along others.

e) Analytical samples, run on -200 mesh pulp, are selected at [E], leading to assays #5 and #6.

Errors generated by the selected procedural steps of Figure 2 are judged by variances of populations of differences between replicate assay values. These variances are calculated, per formulation (1) discussed above, for pairs of values considered as follows:

a) Assay #1 versus assays #2, #3, #4, #5, and #6 produce variance [A]

b) Assay #2 versus assays #3, #4, #5, and #6 produce variance [B].

c) Assay #3 versus assays #4, #5, and #6 produce variance [C].

d) Assay #4 versus assays #5 and #6 produce variance [D].

e) Assay #5 versus #6 produces variance [E], the analytical error.

## REDUCING THE VARIANCE

Reduction of excessive variance in part depends on available equipment and other logistical considerations, budgets, and project objectives. However, in order to avoid potentially devastating problems, a troublesome sample preparation step can be replaced with a step which reduces sample grain size, increases sample volume, and/or both. (Analytical variance might be reduced by using 2 or 3 AT; ie: "increasing volume".)

A minimum of several samples can be reprocessed, using the modified procedure. After accumulating paired replicate assay values from modified steps, the general approach as described above is repeated. Variance for differences between replicate assay values generated by volume-reduction steps should not exceed $(11.5\%)^2$. Establishing this fact will test if modifications have effectively optimized sampling procedures. The optimized sampling procedure should spread increments of error more-or-less evenly among the several steps of sample preparation and analysis.

After establishing an effective procedure, sample preparation and analysis should be routinely monitored for precision and accuracy during the drilling program. Excessive error from careless personnel, laboratory mistakes, changed ore characteristics, etc., otherwise may flaw assay data unexpectedly.

## CONCLUSION

In preparation and analytical procedures for drillhole samples, ineradicable errors can destroy representativity of a sample. Such errors, which may fatally flaw a project, typically come from sample volume reduction and from assay procedures. Drillsite splitting steps commonly cause very substantial errors.

The key to optimizing sampling procedure and reasonably minimizing error resides with an explorationist who understands the sampling process. Comparison of procedurally identical replicate samples from bulk rejects of ore-grade intercepts provides a way to examine error.

Replicate samples, taken at a volume-reduction step in a drillhole sampling procedure, generate replicate assay values whose relative differences constitute a population of data. The variance of this population of differences can be used to judge error generated by the step which inaugurated the pair. A variance of more than $(11.5\%)^2$ for such data from any single step is considered excessive.

A procedural step can be redesigned if it generates non-representative assay data due to excessive variance. For a sample, excessive variance is minimized by increasing volume or by reducing particle size at a troublesome step. The modified procedure is tested for effectiveness and routinely monitored throughout the program to ensure continuing reliability of assay data.

An explorationist should avoid the unpleasant consequences of discovering, at the end of a drilling program, that assay data does not reasonably reflect samples taken. It may then be too late to solve the problem.

Acknowledgments: Thanks are due to Freeport McMoRan Gold Company for permission to publish this paper, and to Francis Pitard of Lakewood, Colorado, for teaching that a procedural step which increases variance of the assay value population by more than $(16\%)^2$ can lead to non-representative data.

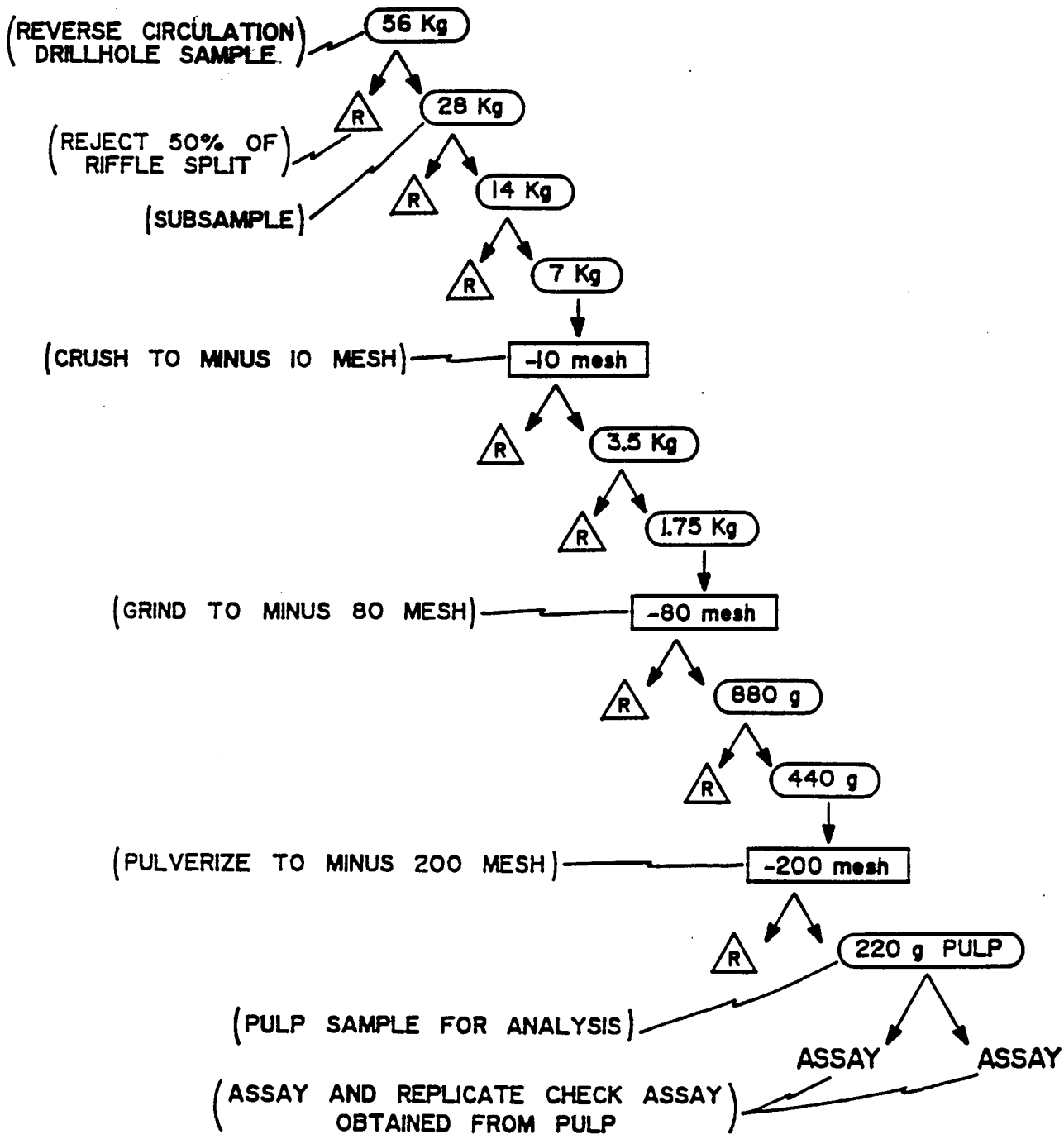



Figure I. REVERSE CIRCULATION DRILLHOLE SAMPLING and ANALYTICAL PROCEDURE

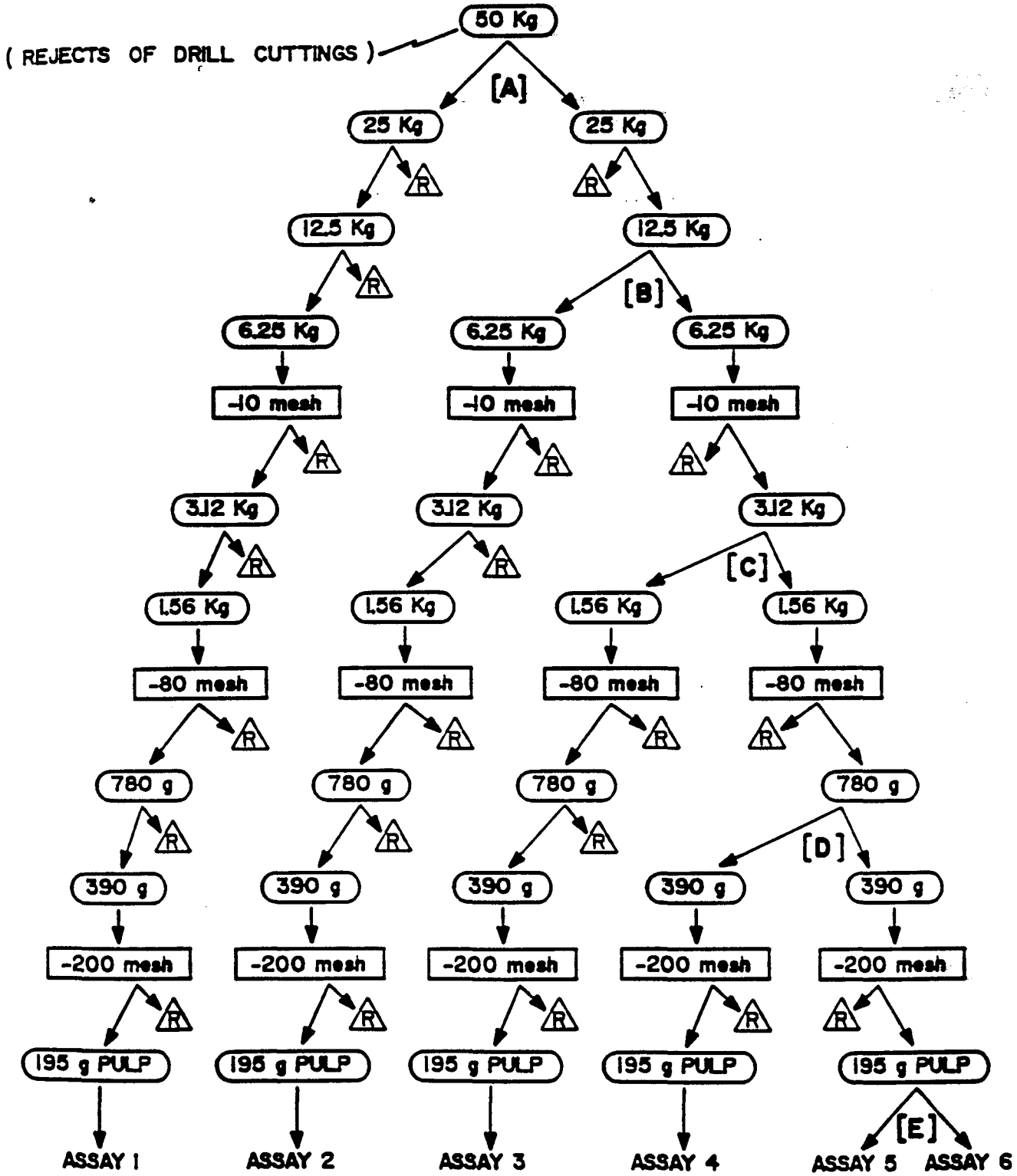



Figure 2. ASSAY STUDY OF REVERSE CIRCULATION DRILLHOLE SAMPLING and ANALYTICAL PROCEDURE

tered lense from below in the form of diminished amplitude and a downward bending of the lower event. This downward bending suggests lower velocity which equates with less competent rock suggesting more intense alteration. The area of low amplitude signal immediately below the large amplitude events is a function of the AGC (automatic gain control) and is not directly related to the geology. For interpretation purposes, it is useful in comparing this anomaly to others such as the section to the right.

In the left section, the AGC exerted a great deal of suppression to the signals originating from the altered zone, thus the area of low amplitude immediately below the amplitude anomaly. The right section depicts events of much lesser amplitude and coherence in the same region, but without the suppressed signal below the events. These lesser events originate along strata in proximity to an unmineralized portion of the thrust fault. No drilling data have been released at the time this paper was written, however strong circumstantial evidence indicates the above observations to be valid.

**James W. Cooksley**
**Peter H. Kendrick**
*Cooksley Geophysics, Inc.*
*Redding, California, U.S.A.*
*Phone 913-241-3167*

**References**

Barnes, H. L., 1979. Geochemistry of hydrothermal ore deposits, second edition: John Wiley & Sons
Bonham, H. F., Jr., Tingley, J. V., eds. 1986, Sediment-hosted precious-metal deposits of northern Nevada: Nevada Bureau of Mines and Geology, Report 40, 11 authors, 103 pp.
Radtke, A. S., 1985. Geology of the Carlin gold deposit: U. S. Geologic Survey Professional Paper 1267, 124 pp.

# A Check for Error in Drill Hole Sampling Using Paired Assays

## Introduction

In advanced stages of exploration, check assays are commonly run on analytical samples, but the many steps which ready a sample for assay are not often checked. This situation invites unpleasant problems with data quality. Inappropriate sample processing can fatally flaw resource investigations and mine planning.

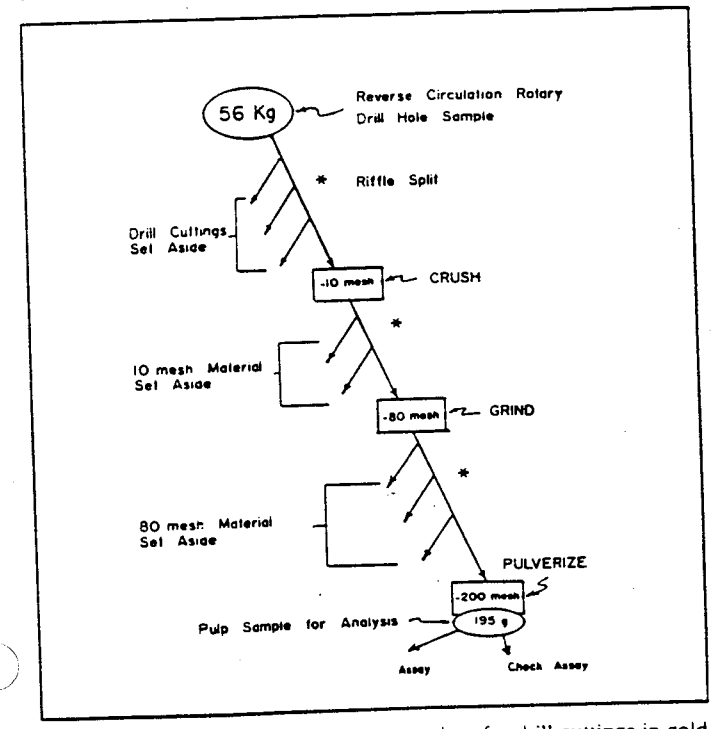



**Figure 1.** An expedient sampling procedure for drill cuttings in gold exploration.

## Error in Assay Values

Every splitting, comminution, and analytical procedure in sampling introduces an increment of error into assay values. Splitting steps, including selection of the assay charge, typically impose the worst sampling errors, but the worst *splitting* errors often involve drill cuttings. As only minor errors accrue from careful comminution, digestion, dilution, instrumental analysis, etc., only sample splitting will be considered here.

Subsample inhomogeneity caused by inappropriate splitting procedures creates a subsample distribution which no longer represents the true sample distribution. What in effect is created is an inseparable combination of true and artificial distributions which can not be adaquately characterized by either statistics or geostatistics. Since most assay values in distributions of this sort typically report lower than true, and a few much higher than true, and since high "erratic" assays are often cut, ore grades above cutoff can be underestimated. Consequently, grade boundaries tend not to be realistic.

Thus, an expedient sampling procedure – used for the first few holes in a continuing project – must be checked. Sampling steps which generate non-representative assays and excessive error must be redesigned so that subsequent drilling and sample processing can provide reliable assays for resource estimation and mine planning. A relative variance of $(11.5\%)^2$ to $(16\%)^2$ (Schwarz, 1989) measures the maximum tolerable limit for error from a single sampling step.

## Estimating Error

Error generated at any volume-reduction step is investigated by use of paired assays. Replicate samples from several ore-grade intercepts are isolated at the splitting step in question and processed in the same way as the original samples. Resulting assay values are transformed as follows:

$$\% \text{ difference} = 100 \times (\mathbf{O}-\mathbf{R}) \div (\mathbf{O}+\mathbf{R}) \qquad (1)$$

for original **O** and replicate **R** assays. Relative variance of "% difference", calculated by the usual formulation, estimates error in units of percentage$^2$ for a given splitting step. If the sigma key of a pocket calculator is used to tabulate values from (1) above, tedious mathematical manipulations are avoided, and the relative variance is easily calculated.

Material selected from a narrow range of assay values will avoid problems with sample value distribution. If the project geologist

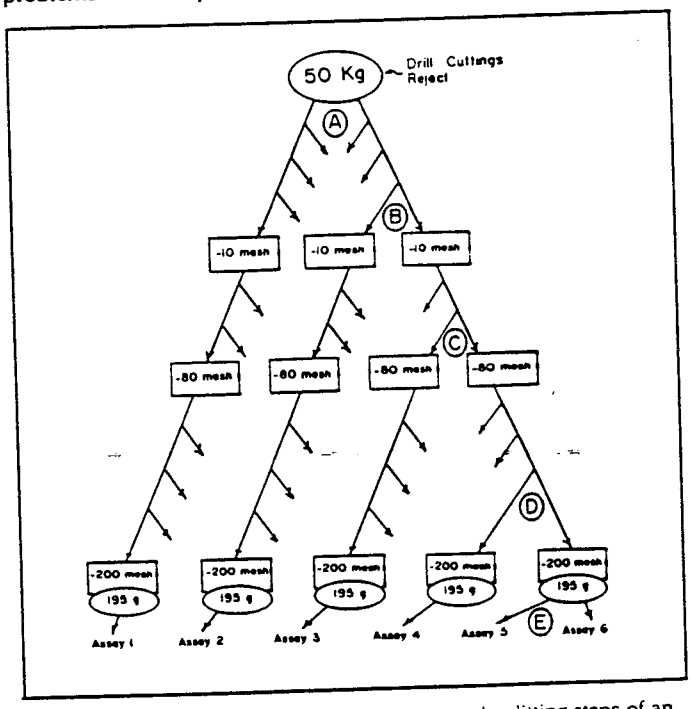



**Figure 2.** Paired samples isolated from several splitting steps of an expedient procedure for a check of sampling error using paired assays. Resulting paired assays can check sampling error.

checks samples which report ore grades near cutoff, the critical ore/waste boundry is also examined. If several intercepts in a narrow range of assay values are not available, a broader range may be used after logarithmic conversion. These can substitute for original and replicate values in (1) above.

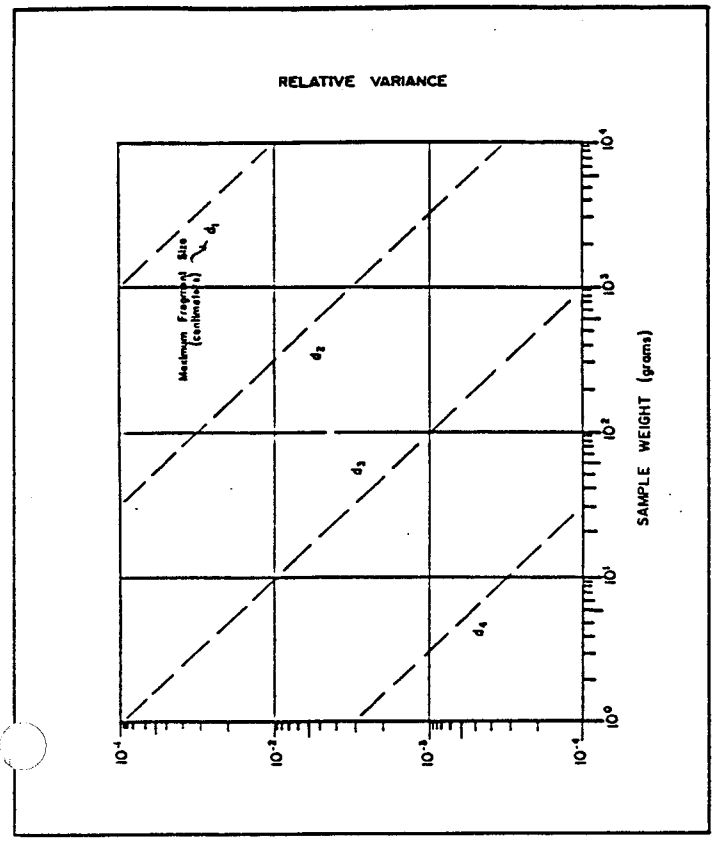



**Figure 3** An example sampling nomograph (modified from Gy and Pitard, 1989)

## Example Procedure

Figure 1 shows an expedient sampling procedure used at start-up of a rotary reverse circulation drilling program. The initial sample, 56 kg of material, comes from a 5-ft drill intercept. This material is riffle-split to convenient subsamples which are crushed, ground, and pulverized to provide the analytical sample. Since the worst errors typically come from splits of coarse materials, uncrushed cuttings and laboratory rejects must be temporarily stored to later provide replicate samples for procedural checking.

Figure 2 shows several splitting steps isolated for checking. The splitting step at **A** provides replicate Assay #1 paired with original Assay #5. Assay #1 can also be paired with #2, #3, and #4. These assays generate an estimate of variance at **A**. Similarly, splits at **B**, **C**, **D**, and at the analytical check **E**, provide replicate/original assay pairs which generate a variance for each splitting step.

Checking can conveniently begin with splitting steps immediately preceeding comminution – **B** and then **C** in Figure 2, and so forth. (If **B** does not generate excessive error, splitting steps above **B** are O.K. Similarly, at **C**, etc.) Either reprocessed or stored material can be used.

## Redesign

Modification of potentially devastating sample splitting steps is easily justified for an ongoing project. Considering that redesign depends on logistics, budgets, and project objectives, the project geologist can minimize error by replacing problem steps with procedures which reduce grain size at a larger sample volume.

The project geologist can simply replace a troublesome step and test the modified procedure. Since such iterative work is tedious and expensive, it is preferrable to work the problem on paper.

When relative variance at several sampling steps is determined, these data characterize not only the sampling procedure, but also the material itself. Thus, any similar method for processing this material can also be characterized.

Several variances calculated at different sample volumes and various particle sizes are used to construct a "sampling nomograph" (Gy et al, 1989). The nomograph uses the general relationship:

log variance is proportional to 3 log **d** − log **m** (2)

where variance is the decimal % relative variance, **d** is the centimeter screen size passing 95% of material, and **m** is sample weight in grams.

A calculated variance at known **m**, a variance/m point, is plotted on the nomograph (Figure 3). The known **d** at each variance/m point also defines a nomograph line with a slope of negative one (see (2) above). This line shows the range of possible variance/m points for the given **d**. Alternate **d**'s can be extrapolated from plotted lines representing known **d**'s.

At a comminution step, **m** holds constant while **d** and variance decrease; at a sample splitting step, **d** holds constant while variance and **m** decrease. Graphical manipulation of **m** and **d** can consider and weigh: logistics and budgets; the limit of an acceptable variance $(15\%)^2$, for example, plotted as .0225 decimal % difference); and the advisability of spreading increments of error more-or-less evenly among the splitting steps. Thus, the nomograph can predict variance, **D**, and **m** and suggest design modifications without the need to iterate sampling procedures.

After redesign, the modified procedure should be checked for excessive error. As the project continues, sampling should be continually and routinely monitored. Even in the best programs, carelessness, changed ore characteristics, equipment problems, etc. can flaw assay data unexpectedly and increase data variance.

A project geologist should avoid the consequences of discovering, at the end of an advanced drilling program, that assay data for which he is responsible does not reasonably reflect samples taken. It may then be too late to resolve this very unpleasant situation.

Thanks to Freeport McMoRan Gold Company for permission to share these thoughts.

**Frederick P. Schwarz, Jr.**
*Freeport McMoRan Gold Co.*
*Mountain City Star Route*
*Elko, Nevada 89801*

### References Cited

Gy, Pierre, and Pitard, Francis, 1989. Sampling of gold, theory and practice: Colorado School of Mines short course, October 1988.

Schwarz, F. P., 1989. Minimizing errors in drill sampling for gold: Proceedings, SME/AusIMM Gold '89 symposium, pp 33-37.

ASARCO

Southwestern Exploration Division

JDS

July 27, 1990

J.D. Sell

Alvarado Mine
Yavapai County, AZ

I talked to Raul Madrid, Conquistador Gold, regarding the Alvarado Mine. They will be sending us a complete data package next month on all their work on the property. This includes both surface and underground mapping and sampling. According to Raul, they plan to go public within 2-3 months, but are looking for a joint venture partner on the property. No terms were discussed.

Mark A. Miller

MAM:mek

**ASARCO**

**Southwestern Exploration Division**

July 27, 1990

S.L. Lakosky, Jr.

Yarnell Project
Pennsylvania No. 1
Additional Exploration
Drilling

A memo by Mark Miller on January 30, 1990, requested additional drilling that would have included drill holes on the west side of the Pennsylvania No. 1. This request was not approved.

In order to increase our odds of taking the Pennsylvania to patent, more exploration drilling on the west side of the claim could give an additional ±500,000 tons of ore @ ±0.05 opt (estimate according to M. Miller's report 1/30/90).

William D. Gay

WDG:mek

William D. Gay

cc: T.E. Scartaccini
W.L. Kurtz
J.D. Sell
M.A. Miller

# ASARCO

**Exploration Department**
Southwestern United States Division

July 27, 1990

Mr. J. Yannuzzi
Y.O.U.
527 South Church St.
Hazelton, PA 18201

Dear Jack:

Enclosed is an outline of documents that are required with the mineral patent application.

The two items needed are highlighted.

#3 Atomic Bomb Project - need an affidavit that states something like "Western Building has or has had no part, direct or indirect in the development of the Atomic Bomb Project."

#4 Corporation - as we discussed, and is self-explanatory as to what the BLM requires.

Sincerely yours,

William D. Gay

William D. Gay
Land Engineer, SWED

WDG:mek
Enc.

cc: W.L. Kurtz
J.D. Sell

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

DOCUMENTS THAT ARE REQUIRED WITH A MINERAL PATENT APPLICATION

For more detailed information see: Guidelines for Mineral Applications in Arizona and 43 Code of Federal Regulations Part 3860.

1. Nonrefundable service charge of $250 per application and the initial mining claim or site plus $50 for each additional mining claim or site and transmittal letter.

2. Application for patent in Narrative form filed in duplicate, signed within the State and filed within 10 days of signing. If applicant does not live in the State a duly authorized agent within the State can sign the application or the applicant can sign while in the State. Should include: Name of contiguous claims, Mineral Survey number and/or legal description, acreage applied for, list of exclusions and adjacent claims, claimant's right of and origin of possession (chain of title), basis of his claim to a patent, description of the kind and character of the vein or lode, amount and value of ore that has been removed, precise place where vein or lode is exposed and the width, sufficient information to allow a mineral examiner to confirm the discovery on each claim during a field examination; assay reports & sales receipts or any data available to support mineral values prevailing on claim.

nothing here about total minerals data in actual of claim to be patented

3. Atomic Bomb Project: For mining claims located after August 1, 1946, the application must state whether the claimant has or has not had any direct or indirect part in the development of the atomic energy program.

4. Citizenship:
Individual - Signed statement showing native or naturalized, date and place of birth and present address.
Corporation - A certified copy of the charter or certificate of incorporation. A certificate of good standing in the State.

5. Certificate of Title, Form 3860-2, dated just prior to the date of application. A supplemental certificate of title should be submitted shortly thereafter to include the date of filing the application.

ok 6. County certified notices of location (with any amendments).

AS 2000 Incorporated

JUN 22 1990

7. Plat of survey and field notes (2 copies each).

8. Notice of Intention to Apply for Patent in duplicate. Should include: date of posting, name of claimant, name of claims, survey number and/or legal description, mining district, county, adjoining and conflicting claims and exclusions.

9. Proof of Posting of Notice of Intention to Apply for Patent and plat of survey. Statement by 2 witnesses in duplicate should state the date and the conspicuous place of posting on the claim.

10. Proof of improvements for patenting placer claims. The proof of improvements must show their value to be not less than $500 and that they were made by the applicant for patent or his grantors. This proof should consist of the statement of two or more disinterested witnesses.

11. Certificate of Expenditures, Form 3860-8, in duplicate, on surveyed claims; or for claims located by legal description, statements in duplicate as to the description and value of the improvements by 2 witnessess.

12. Statement of no known veins (placer claims only) by two or more witnesses.

13. Mill Sites Only - Statement by two or more persons capable from acquaintance with the land to testify that the land claimed is nonmineral in character.

14. Publisher's Agreement - A statement that the publisher agrees to publish and hold the applicant alone responsible for the cost. (Newspaper to be designated by BLM before filing application.)

15. Draft of Notice to be Published should include: application serial number, BLM address, date of posting, name of claimant, name of claim, mineral survey number and/or legal description, section, township and range, mining district, county, tie to nearest U.S. mineral monument or corner of public land survey, perimeter boundary of claims by course and distrance, names of conflicting and adjoining claims, exclusions, recording data and a statement to file any adverse claims within the 60 day period of publication.

THE FOLLOWING ITEMS WILL BE REQUESTED BY THE BUREAU OF LAND MANAGEMENT AFTER THE PUBLICATION PERIOD:

16. Purchase Money.

17. Proof of Publication (affidavit of publisher with clipping of news item).

18. Statement by the applicant or his authorized agent of continuous posting of notice and plat on the claim during the entire 60 day period of publication.

19. Statement by the applicant of fees and charges.

JDS

**ASARCO** Southwestern Exploration Division

July 27, 1990

J.D. Sell

Lime Green Clay
Yarnell Project
Yavapai County, AZ

## Conclusion

XRD work performed on a lime green clay commonly found as open space filling in fractured areas of the hanging wall reveal it to be nontronite $Na_{0.33}\ Fe_2^{+3}\ (Al,Si)_4\ O_{10}\ (OH)_2\ .\ n\ H_2O$, an iron rich member of the montmorillonite subgroup.

## Introduction

As instructed by J.D. Sell, X-ray diffraction work done by the UofA was performed to identify a lime green clay mineral (sample attached to file copy) that had been observed in both drill cuttings and in outcrop. The X-ray diffraction pattern only produced 3 peaks; therefore, the computer program requiring 4 peaks could not be used. Another problem encountered was that the powder sample pattern (Attach. 1) produced inconclusive results with regard to the clay being montmorillonite or a non expanding/contracting chlorite due to the 100% peak being in the range expected for either clay (14-15 angstroms).

Further tests were performed to resolve the montmorillonite/chlorite problem. These tests included:

1) Glycolation of sample to XRD to hydrate the sample.

   a) If montmorillonite, the 100% peak will shift. On Attachment 1 the untreated 100% value is 6.00° 2-theta and is equivalent to a d-spacing of 14.7 angstroms (Table 1, attached); whereas on Attachment 2 the glycol treated 100% value is 5.35° and is equivalent to 16.5 angstroms showing nearly a 2 angstrom shift.

   b) If chlorite, no shift will occur.

2) Preheating the sample to 300°C for 1 hour prior to XRD to dehydrate the sample.

   a) If montmorillonite, the 100% peak will shift the opposite direction as the glycolation procedure caused. On Attachment 1, the untreated 100% value is 6.00° 2-theta, equivalent to 14.7 angstroms; whereas on Attachment 3, the dehydrated value, 9.2° 2-theta is equivalent to 9.6 angstroms representing a peak shift in the opposite direction of the glycolation procedure.

   b) If chlorite, no shift will occur.

As shown in Table 2 (attached), the various clay minerals react differently to the two above tests. Note that chlorite should show no peak shift whereas montmorillonite does show a peak shift.

Interpretation

Due to the appropriate magnitude of shifting of the 100% peak as a result of glycolation and drying, one can conclude that the clay belongs to the montmorillonite group. Further observation of the powder sample (Attachment 1) pattern reveals the presence of peaks corresponding to 1.5 and 4.5 angstroms which are diagnostic of nontronite (highlighted in Table 3).

The presence of nontronite was observed in the field in association with open space filling of fractures within the hanging wall. Furthermore, whole rock analysis of the altered footwall green core (sericitized and silicified) revealed low concentrations of Na and Fe as compared to unaltered samples.

I feel that the low Na and Fe concentrations in the footwall and the presence of a Na and Fe rich clay in fractures of the hanging wall indicate a mobilization of Na and Fe from the footwall to the hanging wall. Mechanisms responsible for the Fe mobilization are not clear; however, the Na mobilization is probably due to the excess sodium produced during sericitization.

Recommendations for further work would include a suite of samples that represent the full range of alteration assemblages seen at Yarnell (probably 5 more samples needed to do this) for whole rock analysis. This would help delineate the chemistry of the Yarnell System so that

some "clear cut" answers can be made about what elements are being introduced, remobilized or are stable.

John J. Malusa

JJM:mek
atts.

cc: W.L. Kurtz
M.A. Miller

Table 1



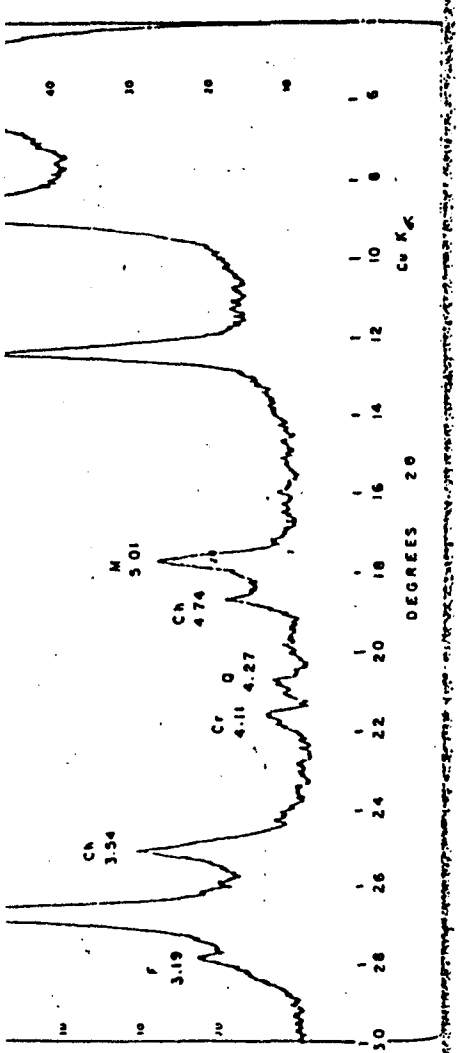
[redacted]. Table for conversion of $2\theta$ angles (CuK$\alpha$) to interplanar spacing ($d$)
[From Switzer and others (1948)]

| $2\theta$ | .0 | .1 | .2 | .3 | .4 | .5 | .6 | .7 | .8 | .9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 44.171 | 42.068 | 40.156 | 38.410 | 36.180 | 35.338 | 33.979 | 32.721 | 31.552 | 30.464 |
| 3 | 29.449 | 28.499 | 27.609 | 26.773 | 25.985 | 25.243 | 24.542 | 23.879 | 23.251 | 22.655 |
| 4 | 22.089 | 21.550 | 21.037 | 20.548 | 20.082 | 19.636 | 19.209 | 18.800 | 18.409 | 18.034 |
| 5 | 17.673 | 17.327 | 16.994 | 16.673 | 16.365 | 16.068 | 15.781 | 15.504 | 15.237 | 14.979 |
| 6 | 14.730 | 14.488 | 14.255 | 14.029 | 13.810 | 13.598 | 13.392 | 13.192 | 12.998 | 12.810 |
| 7 | 12.628 | 12.450 | 12.277 | 12.109 | 11.946 | 11.787 | 11.632 | 11.481 | 11.334 | 11.191 |
| 8 | 11.051 | 10.915 | 10.782 | 10.652 | 10.526 | 10.402 | 10.281 | 10.163 | 10.048 | 9.9355 |
| 9 | 9.8254 | 9.7176 | 9.6122 | 9.5091 | 9.4082 | 9.3093 | 9.2126 | 9.1178 | 9.0250 | 8.9341 |
| 10 | 8.8450 | 8.7576 | 8.6720 | 8.5880 | 8.5057 | 8.4249 | 8.3456 | 8.2678 | 8.1915 | 8.1166 |
| 11 | 8.0430 | 7.9708 | 7.8998 | 7.8302 | 7.7617 | 7.6944 | 7.6283 | 7.5634 | 7.4995 | 7.4367 |
| 12 | 7.3750 | 7.3142 | 7.2545 | 7.1957 | 7.1379 | 7.0810 | 7.0251 | 6.9699 | 6.9157 | 6.8624 |
| 13 | 6.8098 | 6.7580 | 6.7071 | 6.6569 | 6.6074 | 6.5587 | 6.5107 | 6.4634 | 6.4168 | 6.3708 |
| 14 | 6.3256 | 6.2809 | 6.2369 | 6.1935 | 6.1507 | 6.1085 | 6.0669 | 6.0259 | 5.9854 | 5.9454 |
| 15 | 5.9060 | 5.8671 | 5.8288 | 5.7909 | 5.7535 | 5.7166 | 5.6802 | 5.6442 | 5.6088 | 5.5737 |
| 16 | 5.5391 | 5.5049 | 5.4711 | 5.4378 | 5.4049 | 5.3723 | 5.3402 | 5.3084 | 5.2771 | 5.2461 |
| 17 | 5.2154 | 5.1852 | 5.1552 | 5.1257 | 5.0964 | 5.0675 | 5.0390 | 5.0107 | 4.9828 | 4.9552 |
| 18 | 4.9279 | 4.9009 | 4.8742 | 4.8478 | 4.8216 | 4.7958 | 4.7702 | 4.7450 | 4.7199 | 4.6952 |
| 19 | 4.6707 | 4.6465 | 4.6225 | 4.5988 | 4.5753 | 4.5521 | 4.5291 | 4.5063 | 4.4838 | 4.4615 |
| 20 | 4.4394 | 4.4175 | 4.3959 | 4.3744 | 4.3532 | 4.3322 | 4.3114 | 4.2908 | 4.2704 | 4.2502 |
| 21 | 4.2302 | 4.2104 | 4.1907 | 4.1713 | 4.1520 | 4.1329 | 4.1140 | 4.0953 | 4.0767 | 4.0583 |
| 22 | 4.0401 | 4.0220 | 4.0042 | 3.9864 | 3.9689 | 3.9515 | 3.9342 | 3.9171 | 3.9001 | 3.8833 |
| 23 | 3.8667 | 3.8502 | 3.8338 | 3.8176 | 3.8015 | 3.7855 | 3.7697 | 3.7540 | 3.7385 | 3.7231 |
| 24 | 3.7078 | 3.6926 | 3.6776 | 3.6627 | 3.6479 | 3.6332 | 3.6187 | 3.6043 | 3.5900 | 3.5758 |
| 25 | 3.5617 | 3.5477 | 3.5339 | 3.5201 | 3.5065 | 3.4930 | 3.4796 | 3.4662 | 3.4530 | 3.4399 |
| 26 | 3.4269 | 3.4140 | 3.4012 | 3.3885 | 3.3759 | 3.3634 | 3.3510 | 3.3386 | 3.3264 | 3.3143 |
| 27 | 3.3022 | 3.2903 | 3.2784 | 3.2666 | 3.2549 | 3.2433 | 3.2318 | 3.2203 | 3.2090 | 3.1977 |
| 28 | 3.1865 | 3.1754 | 3.1644 | 3.1534 | 3.1426 | 3.1318 | 3.1210 | 3.1104 | 3.0998 | 3.0893 |
| 29 | 3.0789 | 3.0685 | 3.0582 | 3.0480 | 3.0379 | 3.0278 | 3.0178 | 3.0079 | 2.9980 | 2.9882 |
| 30 | 2.9785 | 2.9688 | 2.9592 | 2.9497 | 2.9402 | 2.9308 | 2.9214 | 2.9122 | 2.9029 | 2.8938 |
| 31 | 2.8847 | 2.8756 | 2.8666 | 2.8577 | 2.8488 | 2.8400 | 2.8312 | 2.8225 | 2.8139 | 2.8053 |
| 32 | 2.7968 | 2.7883 | 2.7798 | 2.7715 | 2.7631 | 2.7549 | 2.7466 | 2.7385 | 2.7303 | 2.7223 |
| 33 | 2.7143 | 2.7063 | 2.6984 | 2.6905 | 2.6827 | 2.6749 | 2.6671 | 2.6595 | 2.6518 | 2.6442 |
| 34 | 2.6367 | 2.6292 | 2.6217 | 2.6143 | 2.6069 | 2.5996 | 2.5923 | 2.5851 | 2.5779 | 2.5707 |
| 35 | 2.5636 | 2.5565 | 2.5495 | 2.5425 | 2.5355 | 2.5286 | 2.5218 | 2.5149 | 2.5081 | 2.5014 |
| 36 | 2.4947 | 2.4880 | 2.4813 | 2.4747 | 2.4682 | 2.4616 | 2.4551 | 2.4487 | 2.4422 | 2.4358 |
| 37 | 2.4295 | 2.4232 | 2.4169 | 2.4106 | 2.4044 | 2.3982 | 2.3921 | 2.3860 | 2.3799 | 2.3738 |
| 38 | 2.3678 | 2.3618 | 2.3559 | 2.3500 | 2.3441 | 2.3382 | 2.3324 | 2.3266 | 2.3208 | 2.3151 |
| 39 | 2.3094 | 2.3037 | 2.2981 | 2.2924 | 2.2869 | 2.2813 | 2.2758 | 2.2703 | 2.2648 | 2.2593 |
| 40 | 2.2539 | 2.2485 | 2.2432 | 2.2378 | 2.2325 | 2.2273 | 2.2220 | 2.2168 | 2.2116 | 2.2064 |
| 41 | 2.2012 | 2.1961 | 2.1910 | 2.1859 | 2.1809 | 2.1759 | 2.1709 | 2.1659 | 2.1609 | 2.1560 |
| 42 | 2.1511 | 2.1462 | 2.1414 | 2.1365 | 2.1317 | 2.1270 | 2.1222 | 2.1175 | 2.1127 | 2.1080 |
| 43 | 2.1034 | 2.0987 | 2.0941 | 2.0895 | 2.0849 | 2.0804 | 2.0758 | 2.0713 | 2.0668 | 2.0623 |
| 44 | 2.0579 | 2.0534 | 2.0490 | 2.0446 | 2.0402 | 2.0359 | 2.0316 | 2.0273 | 2.0230 | 2.0187 |
| 45 | 2.0144 | 2.0102 | 2.0060 | 2.0018 | 1.9976 | 1.9935 | 1.9893 | 1.9852 | 1.9811 | 1.9770 |
| 46 | 1.9729 | 1.9689 | 1.9649 | 1.9609 | 1.9569 | 1.9529 | 1.9489 | 1.9450 | 1.9411 | 1.9372 |
| 47 | 1.9333 | 1.9294 | 1.9255 | 1.9217 | 1.9179 | 1.9141 | 1.9103 | 1.9065 | 1.9028 | 1.8990 |
| 48 | 1.8953 | 1.8916 | 1.8879 | 1.8842 | 1.8806 | 1.8769 | 1.8733 | 1.8697 | 1.8661 | 1.8625 |
| 49 | 1.8589 | 1.8554 | 1.8519 | 1.8483 | 1.8448 | 1.8413 | 1.8378 | 1.8344 | 1.8309 | 1.8275 |
| 50 | 1.8241 | 1.8207 | 1.8173 | 1.8139 | 1.8105 | 1.8072 | 1.8039 | 1.8005 | 1.7972 | 1.7939 |

untreated

treated

tabl 2




m of oriented mount of clay typical
lat 35° 00′ N., 165° 00′ W., northe
chart, Dorothy Carroll, unpub.). C
ristobalite; F, feldspar.

TABLE 9. X-RAY IDENTIFICATION OF THE PRINCIPAL CLAY MINERALS (<2 MICRONS) IN AN ORIENTED MOUNT OF A SEPARATED CLAY FRACTION FROM SEDIMENTARY MATERIAL*

| Mineral | Basal *d* spacings (001) | Glycolation effect; 1 hour, 60°C | Heating effect, 1 hour |
|---|---|---|---|
| Kaolinite | 7.15Å (001); 3.75Å (002) | No change | Becomes amorphous 550-600°C |
| Kaolinite, disordered | 7.15Å (001) broad; 3.75Å broad | No change | Becomes amorphous at lower temperatures than kaolinite |
| Halloysite, $4H_2O$ | 10Å (001) broad | No change | Dehydrates to $2H_2O$ at 110°C |
| Halloysite, $2H_2O$ | 7.2Å (001) broad | No change | Dehydrates at 125-150°C; becomes amorphous 560-590°C |
| Mica, 2M | 10Å (002); 5Å (004) generally referred to as (001) and (002) | No change | (001) becomes more intense on heating but structure is maintained to 700°C |
| Illite, 1Md | 10Å (002), broad, other basal spacings present but small | No change | (001) noticeably more intense on heating as water layers are removed; at higher temperatures like mica |
| Montmorillonite Group | 15Å (001) and integral series of basal spacings | (001) expands to 17Å with rational sequence of higher orders | At 300°C (001) becomes 9Å (Fig. 5) i.e. shrinks |
| Vermiculite | 14Å (001) and integral series of basal spacings | No change | Dehydrates in steps (Fig. 4a) |
| Chlorite, Mg-form | 14Å (001) and integral series of basal spacings | No change | (001) increases in intensity; <800°C shows weight loss but no structural change |
| Chlorite, Fe-form | 14Å (001) less intense than in Mg-form; integral series of basal spacings | No change | (001) scarcely increases; structure collapses below 800°C |
| Mixed-layer minerals | *Regular*, one (001) and integral series of basal spacings | No change unless an expandable component is present | Various, see descriptions of individual minerals |
| | *Random*, (001) is addition of individual minerals and depends on amount of those present | Expands if montmorillonite is a constituent | Depends on minerals present in interlayered mineral |
| Attapulgite (palygorskite) | High intensity *d* reflections at 10.5Å, 4.5Å, 3.23Å, 2.62Å | No change | Dehydrates stepwise (see description) |
| Sepiolite | High intensity reflections at 12.6Å, 4. 31Å, 2.61Å | No change | Do. |
| Amorphous clay, allophane | No *d* reflections | No change | Dehydrates and loses weight |

Table 2

Table 3





## Table of Key Lines—Continued

| Degrees 2θ (CuKα) | | | | | d-spacing values (Å) | | | | | Mineral |
|---|---|---|---|---|---|---|---|---|---|---|
| 52.59(6) | 15.60(9) | 25.79(5) | 30.61 | 41.02(2) | 1.740 | 5.68 | 3.46 | 2.92 | 2.20 | VISEITE |
| 52.79(8) | 52.79(6) | 32.07 | 38.46(1) | 42.43(6) | 1.739 | 3.59 | 2.79 | 2.39 | 2.13 | SIDERITE |
| 53.05(6) | 23.85(5) | 32.68 | 35.33(8) | 40.25(3) | 1.726 | 3.73 | 2.74 | 2.59 | 2.29 | ILMEINITE |
| 53.15(9) | 18.89(9) | 20.91(7) | 27.88(3) | 40.63 | 1.723 | 4.71 | 4.35 | 3.20 | 2.22 | BAYERITE |
| 53.93(5) | 32.19(9) | 37.47 | 64.23(1) | | 1.700 | 2.78 | 2.40 | 1.450 | | LIME |
| 53.93(3) | 32.68 | 35.92(2) | 43.07(9) | 46.85(1) | 1.700 | 2.74 | 2.50 | 2.10 | 1.939 | MAGNESITE |
| 54.20(5) | 33.30 | 35.77(5) | 41.02(2) | 49.59(9) | 1.692 | 2.69 | 2.51 | 2.20 | 1.838 | HEMATITE |
| 54.38(6) | 27.44 | 36.22(5) | 41.41(2) | 44.17(1) | 1.687 | 3.25 | 2.48 | 2.18 | 2.05 | RUTILE |
| 54.69(8) | 26.52 | 42.43(1) | 44.63(5) | | 1.678 | 3.36 | 2.13 | 2.03 | | GRAPHITE |
| 56.33 | 33.05(8) | 37.15(6) | 40.83(5) | 47.47(9) | 1.633 | 2.71 | 2.42 | 2.21 | 1.915 | PYRITE |
| 56.33(9) | 22.28 | 38.81(5) | 42.43(5) | 43.50(5) | 1.633 | 3.99 | 2.32 | 2.13 | 2.08 | DIASPORE |
| 56.45(5) | 25.59(1) | 28.42 | 37.31(5) | 42.43(2) | 1.630 | 3.48 | 3.14 | 2.41 | 2.13 | PYROLUSITE |
| 57.56(8) | 25.59(7) | 35.19(9) | 43.28 | 52.59(9) | 1.601 | 3.48 | 2.55 | 2.09 | 1.740 | CORUNDUM |
| 58.15(9) | 12.48 | 25.15(8) | 32.92(5) | | 1.586 | 7.09 | 3.54 | 2.72 | | CRONSTEDTITE (060) |
| 59.10(5) | 12.43 | 25.08 | 35.62 | | 1.563 | 7.12 | 3.55 | 2.52 | | CHAMOSITE, FERROUS (060) |
| 59.64-60.07(6) | 6.24 | 18.56(9) | 25.08(8) | | 1.550-1.540 | 14.15 | 4.78 | 3.55 | | CHLORITES (060) |
| 60.03(1) | 20.85(3) | 26.68 | 36.67(1) | 50.20(1) | 1.541 | 4.26 | 3.34 | 2.45 | 1.817 | QUARTZ, LOW |
| 60.07-60.51(6-3) | 12.00-12.46 | 24.31-25.22 | 35.62-37.79(8) | | 1.540-1.530 | 7.37-7.10 | 3.66-3.53 | 2.52-2.38 | | SERPENTINES (060) |
| 60.07-60.51(5) | 8.84 | 26.85(9) | 34.22(5) | | 1.540-1.530 | 10.0 | 3.32 | 2.62 | | MICAS, TRIO- (060) |
| 60.20-60.59(6) | 6.18 | 19.29(6) | 37.63(3) | | 1.537-1.528 | 14.3 | 4.60 | 2.39 | | VERMICULITE (060) |
| 60.51(4) | 5.89 | 19.72 | 35.12-33.69(4) | | 1.530 | 15.0 | 4.5 | 2.55-2.66 | | SMECTITE, TRIO- (060) |
| * 60.69(5) | 9.45 | 19.33(4) | 28.60(10-5) | | 1.527 | 9.35 | 4.59 | 3.12 | | TALC (060) |
| → 60.95(5) | 6.09 | 19.72 | 34.91-34.08(6) | | 1.520 | 14.5 | 4.50 | 2.57-2.63 | | MONTRONITE (060) * ← |
| 61.08(4) | 12.53 | 25.30 | 36.52(7) | | 1.517 | 7.06 | 3.52 | 2.46 | | CHAMOSITE, FERRIC (060) |

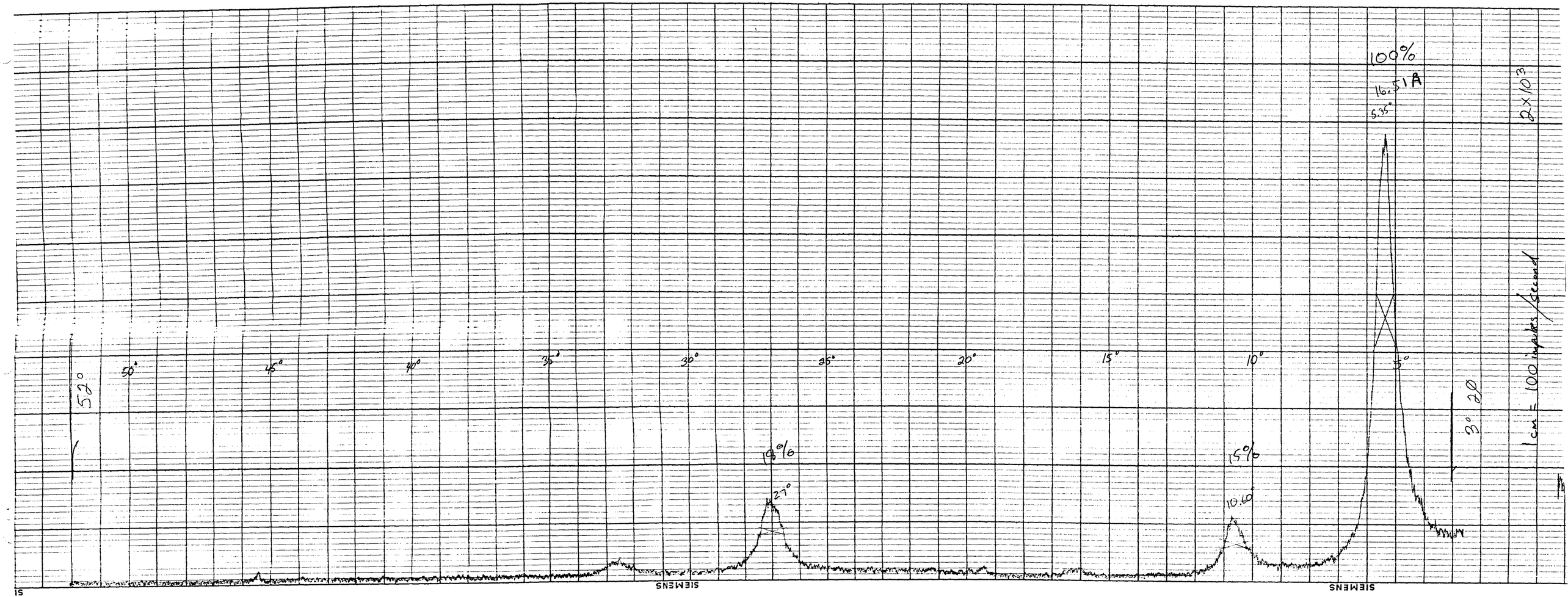
Table 3

~~Dry~~
Clay sample
$1 \times 10^3$
4/24/90
John Malusz

untreated
Attch. 1

degrees 2θ.

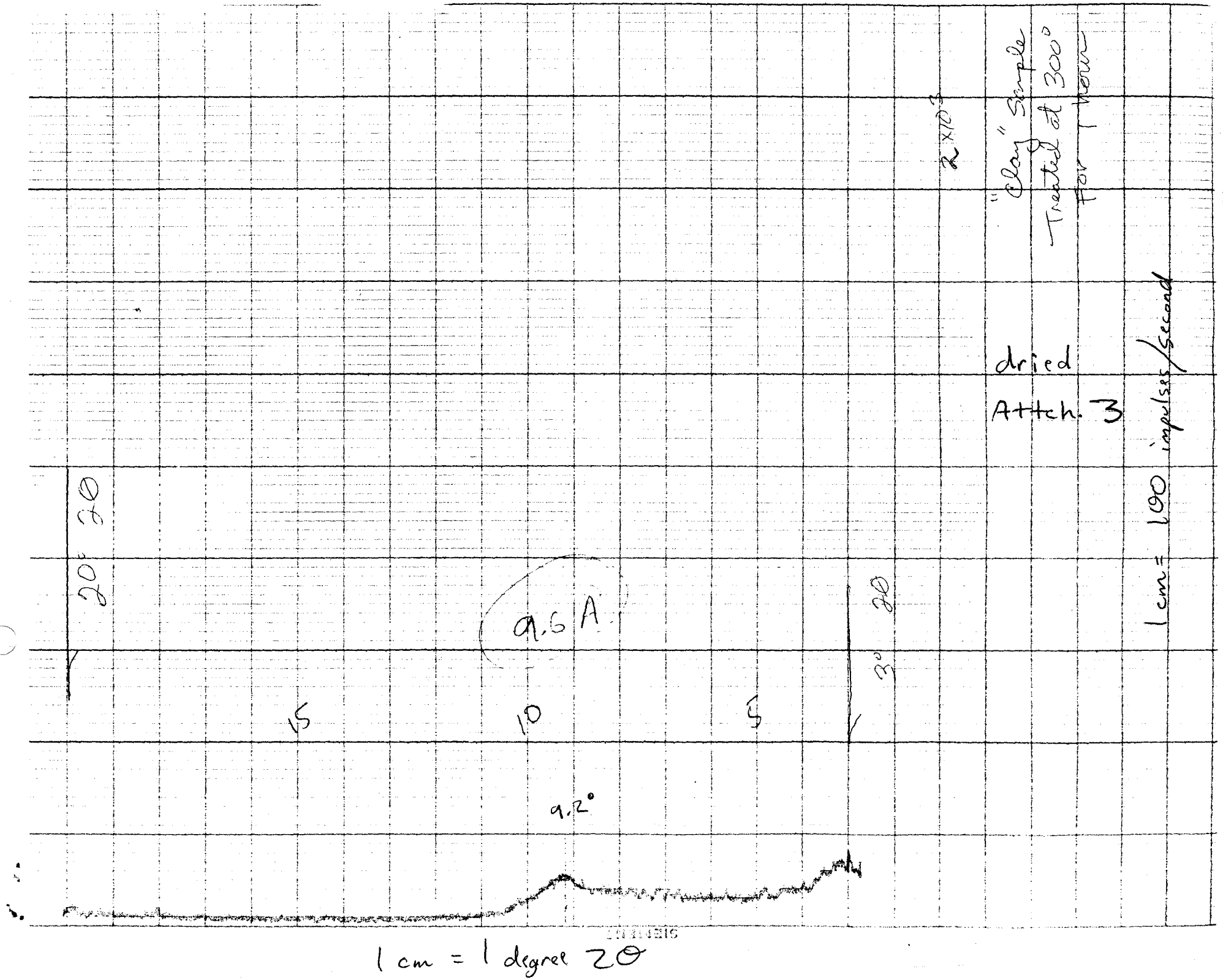
1 cm = 50 impulses/second




degrees 2θ

Attch. 2

Glycol sample


"Clay" Sample
Treated at 300°
For 1 Hour
2 x 10^3
dried
Attch. 3
1 cm = 100 impulses/second
2θ
20°
9.6 A
3°
2θ
15
10
5
9.2°
1 cm = 1 degree 2θ

JDS

**ASARCO**

**Southwestern Exploration Division**

July 30, 1990

J.D. Sell

Pennsylvania Patent Applic.
Yavapai County, Arizona

Bob Fisk of the BLM in Phoenix called on July 30, 1990 with further thoughts on the patenting process. He said that if we start another drilling program on the claim, the BLM would need to verify the location and results of the drilling. They would also request splits of the drill holes for their own assaying.

Mark A. Miller

MAM:mek

cc: W.D. Gay
W.L. Kurtz
S.L. Lakosky

JDS

7-31

FROM: J. D. SELL

TO: MAM

Take your Sept 9, 1989
memo
Original Pulp Assays vs
Repeat Neut Pulp Assays

& include all the
pulp assays, & the
composite footage,
& the composite grade.
Neg calculations as such
& see me. JDS

JDS

APKER, APKER, HAGGARD & KURTZ, P.C.
P. O. Box 10280
Phoenix, Arizona 85064-0280
(602) 381-0085

ASARCO Incorporated
OCT 3 1990
SW Exploration

Exploration Department
Southwestern U.S. Division
ASARCO Incorporated
P.O. Box 5747
Tucson, Arizona 85703-0747

August 1, 1990
Page 1
Client: 111
Matter: 12

Matter: Re: Norgold Resources, Inc.

| Date | Professional Services Rendered |
|---|---|
| 07/05/90 | Telephone conference with Mr. Gay re patenting Pennsylvania claim. |
| 07/09/90 | Telephone conference with Mr. Gay re Pennsylvania patent proceedings. |
| 07/11/90 | Telephone conferences with Mr. Gay; review and revise Pennsylvania amended notice and claim situation; review Western Building agreement; prepare power of attorney and correspondence to Mr. Gay. |
| 07/23/90 | Telephone conferences with Mr. Gay re Pennsylvania patent application. |

Total Services 578.00

Disbursements

Long distance telephone 0.23

Total Disbursements 0.23

Current Charges 578.23

444-04

COPY

* NO.149(AUGUST 2, 1990) * GEORGE CROSS NEWS LETTER LTD. FORTY-THIRD YEAR OF PUBLICATION *

**ASARCO**

**Southwestern Exploration Division**

August 10, 1990

J.D. Sell

REVISED

Original Pulp Assays vs.
Reject New Pulp Assays
Yarnell Project
Yavapai County, Arizona

The corrected memo of September 9, 1989 will be used as a reference (and has been listed as such) and is not included in the final report.

Mark A. Miller

MAM:mek
Atts.

**ASARCO**

**Southwestern Exploration Division**

September 9, 1989

TABLES REVISED August 10, 1990

J.D. Sell

Original Pulp Assays vs.
Reject New Pulp Assays
Yarnell Project
Yavapai County, AZ

The attached tabulations compare the original pulp assay to a new pulp from reject assay. Additionally, the new pulp was refired as there was a possibility of a lab problem. Results of original pulp versus new pulp show a percent change from 0-30% with the new pulp usually higher (Table 2). The refire of the new pulp versus new pulp shows a percent change from 0-20% with a variance of about the same as seen in the original pulp versus new pulp. I do not think that we have a problem in the Assay Lab, but I cannot explain the percent difference in the original versus new assays, particularly since the new assays are higher than original. Perhaps this is a function of the ore?

It seems that the greatest amount of variance was in holes YM-7, 8, 12, 20. This would cover two drilling periods, 1-9, 10-36.

I recommend that we try to resolve this problem by checking 2-3 additional holes within the intervals mentioned (1-9, 10-36) and see if we can isolate the discrepancy. Possibly we can readjust the assays if an upgrade has occurred. Results past the 10-36 holes appear to be within acceptable limits.

Comments please?

Mark A. Miller

MAM:mek

cc: R.L. Brown/F.T. Graybeal
W.L. Kurtz
S.L. Lakosky
(9/27/89)

# YARNELL PROJECT

## ORIGINAL PULP ASSAY VS. REJECT NEW PULP ASSAY

| Original Hole Footage | Original Pulp | New Pulp | New Pulp Refire (Check Refire) | |
|---|---|---|---|---|
| YM-5 | | | | |
| 200-205 | .029 | .051 | .061 | (.062) |
| 210-215 | .195 | .056 | .032 | |
| 215-220 | .02 | .011 | .003 | |
| 220-225 | .001 | .004 | .003 | |
| 225-230 | .011 | .031 | .032 | |
| 230-235 | .055 | .009 | .009 | |
| 235-240 | .006 | .005 | .005 | |
| 240-245 | .051 | .032 | .052 | |
| 245-250 | .013 | .070 | .076 | |
| 255-260 | .024 | .034 | .022 | |
| 260-265 | .027 | .043 | .050 | |
| 265-270 | .025 | .019 | .017 | |
| 270-275 | .010 | .014 | .012 | |
| 275-280 | .013 | .031 | .033 | |
| 280-285 | .014 | .020 | .021 | |
| 285-290 | .065 | .096 | .094 | |
| 330-335 | .004 | .016 | .012 | |
| 345-350 | .037 | .030 | .036 | |
| 200-350 | | | 0-90' | Composite Footage |
| | .033 | .032 | .032 | Composite Grade |
| YM-7 | | | | |
| 155-160 | .024 | .03 | .024 | |
| 160-165 | .016 | .041 | .017 | |
| 165-170 | .034 | .049 | .053 | |
| 170-175 | .091 | .080 | .095 | |
| 175-180 | .055 | .077 | .078 | |
| 180-185 | .142 | .149 | .148 | |
| 185-190 | .02 | .012 | .012 | |
| 190-195 | .011 | .012 | .011 | |
| 195-200 | .053 | .048 | .050 | |
| 200-205 | .036 | .061 | .057 | |
| 205-210 | .042 | .051 | .045 | |
| 210-215 | .062 | .086 | .071 | |
| 215-220 | .056 | .060 | .055 | |
| 225-230 | .022 | .018 | .016 | |
| 155-230 | | | 0-70' | Composite Footage |
| | .047 | .055 | .052 | Composite Grade |

# YARNELL PROJECT

## ORIGINAL PULP ASSAY VS. REJECT NEW PULP ASSAY

| Original Hole Footage | Original Pulp | New Pulp | New Pulp Refire (Check Refire) | |
|---|---|---|---|---|
| **YM-8** | | | | |
| 225-230 | .047 | .066 | .066 | |
| 235-240 | .029 | .055 | .052 | |
| 240-245 | .018 | .025 | .027 | |
| 245-250 | .013 | .018 | .015 | |
| 250-255 | .048 | .056 | .052 | |
| 255-260 | .087 | .108 | .100 | |
| 260-265 | .063 | .093 | .092 | |
| 265-270 | .023 | .049 | .042 | |
| 270-275 | .037 | .046 | .046 | |
| 225-275 | | | 0-45' | Composite Footage |
| | .041 | .057 | .055 | Composite Grade |
| **YM-12** | | | | |
| 150-155 | .013 | .018 | .022 | |
| 155-160 | .068 | .084 | .056 | (.041) |
| 160-165 | .021 | .040 | .035 | |
| 165-170 | .096 | .126 | .094 | (.139) |
| 170-175 | .031 | .053 | .030 | (.029) |
| 175-180 | .074 | .032 | .032 | |
| 180-185 | .008 | .009 | .009 | |
| 195-200 | .018 | .025 | .021 | |
| 200-205 | .049 | .092 | .069 | (.067) |
| 205-210 | .025 | .023 | .020 | |
| 210-215 | .045 | .083 | .070 | |
| 215-220 | .040 | .030 | .026 | |
| 220-225 | .024 | .022 | .022 | |
| 225-230 | .015 | .014 | .021 | |
| 230-235 | .034 | .034 | .023 | (.034) |
| 235-240 | .030 | .043 | .040 | |
| 150-240 | | | 0-~~90~~ 40' | Composite Footage |
| | .036 | .045 | .037 | Composite Grade |
| **YM-20** | | | | |
| 0-5 | .044 | .068 | .060 | |
| 5-10 | .011 | .016 | .017 | |
| 10-15 | .010 | .011 | .016 | |
| 15-20 | .015 | .018 | .013 | |
| 20-25 | .052 | .083 | .052 | (.047) |
| 25-30 | .331 | .386 | .348 | |
| 30-35 | .024 | .032 | .026 | |
| 0-35 | | | 0-35' | Composite Footage |
| | .070 | .088 | .076 | Composite Grade |

# YARNELL PROJECT

## ORIGINAL PULP ASSAY VS. REJECT NEW PULP ASSAY

| Original Hole Footage | Original Pulp | New Pulp | New Pulp Refire (Check Refire) | |
|---|---|---|---|---|
| **YM-24** | | | | |
| 75-80 | .229 | .281 | .261 | |
| 80-85 | .118 | .165 | .164 | |
| 85-90 | .052 | .061 | .061 | |
| 90-95 | .081 | .091 | .087 | |
| 95-100 | .095 | .108 | .092 | |
| 100-105 | .038 | .114 | .102 | |
| 105-110 | .099 | .115 | .106 | |
| 110-115 | .029 | .036 | .034 | |
| 75-115 | | | 0-40' | Composite Footage |
| | .093 | .121 | .113 | Composite Grade |
| **YM-40** | | | | |
| 275-280 | .023 | .030 | .028 | |
| 280-285 | .018 | .020 | .019 | |
| 285-290 | .012 | .023 | .015 | (.013) |
| 290-295 | .129 | .123 | .076 | |
| 295-300 | .036 | .045 | .045 | |
| 300-305 | .041 | .046 | .038 | |
| 305-310 | .027 | .046 | .036 | |
| 310-315 | .177 | .168 | .137 | |
| 315-320 | .071 | .096 | .057 | |
| 320-325 | .013 | .016 | .016 | |
| 325-330 | .021 | .045 | .062 | |
| 330-335 | .162 | .119 | .110 | |
| 335-340 | .043 | .056 | .052 | |
| 340-345 | .034 | .046 | .043 | |
| 355-360 | .131 | .069 | .066 | |
| 360-365 | .043 | .042 | .049 | |
| 365-370 | .079 | .063 | .030 | |
| 370-375 | .033 | .063 | .062 | |
| 375-380 | .018 | .026 | .025 | |
| 345-350 | .108 | .142 | .136 | |
| 350-355 | .081 | .108 | .139 | |
| 275-380 | | | 0-105' | Composite Footage |
| | .062 | .066 | .059 | Composite Grade |
| **YM-3** | | | | |
| 130-135 | .021 | .023 | .028 | |
| 135-140 | .031 | .029 | .027 | |
| 140-145 | .047 | .049 | .044 | |
| 160-165 | .047 | .073 | .081 | |
| 165-170 | .068 | .074 | .064 | |
| 170-175 | .091 | .040 | .041 | |

YARNELL PROJECT

ORIGINAL PULP ASSAY VS. REJECT NEW PULP ASSAY

| Original Hole Footage | Original Pulp | New Pulp | New Pulp Refire (Check Refire) |
|---|---|---|---|
| YM-3 (Continued) | | | |
| 175-180 | .055 | .081 | .062 |
| 180-185 | .035 | .051 | .054 |
| 185-190 | .073 | .107 | .094 |
| 190-195 | .080 | .051 | .101 |
| 195-200 | .129 | .113 | .129 |
| 200-205 | .016 | .010 | .010 |
| 130-205 | | | 0-60' Composite Footage |
| | .058 | .058 | .061 |
| YM-50 | | | |
| 0-5 | .053 | .061 | |
| 5-10 | .081 | .092 | |
| 10-15 | .128 | .119 | |
| 15-20 | .016 | .008 | |
| 20-25 | .010 | .006 | |
| 25-30 | .009 | .009 | |
| 30-35 | .008 | .005 | |
| 35-40 | .008 | .015 | |
| 40-45 | .029 | .017 | |
| 45-50 | .275 | .288 | |
| 50-55 | .011 | .011 | |
| 55-60 | .080 | .062 | |
| 60-65 | .002 | .003 | |
| 65-70 | .081 | .146 | |
| 70-75 | .018 | .011 | |
| 75-80 | .102 | .168 | |
| 80-85 | .173 | .108 | |
| | 85' @ .064 | 85' @ .062 | |
| | -4% Difference between Original & New Pulp | | |
| YM-56 | | | |
| 70-75 | .083 | .058 | |
| 75-80 | .028 | .026 | |
| 80-85 | .027 | .038 | |
| 85-90 | .105 | .091 | |
| 90-95 | .105 | .123 | |
| 95-100 | .128 | .116 | |
| 100-105 | .095 | .104 | |
| | 35' @ .082 | 35' @ .079 | |
| | -4% Difference between Original & New Pulp | | |

TABLE 2

## YARNELL PROJECT

## ORIGINAL ASSAY VERSUS NEW REJECT ASSAY

(% Difference, Weighted Grade for Entire Interval)

| Original Hole # (New Hole #) | Original Hole Assay | New Reject Assay | %Diff.from Orig. Hole | Refire New Pulp | %Diff.from New Reject | %Diff.from Orig. Hole |
|---|---|---|---|---|---|---|
| YM-5 (1A) | .033 | .032 | -3% | .032 | 0 | -3% |
| YM-7 (1B) | .047 | .055 | +15% | .052 | +9% | +10% |
| YM-8 (1C) | .041 | .057 | +30% | .055 | +3.5% | +25.5% |
| YM-12 (1D) | .036 | .045 | +20% | .037 | -18% | +3% |
| YM-20 (1E) | .070 | .088 | +20.5% | .076 | +14% | +8% |
| YM-24 (1F) | .093 | .121 | +24% | .113 | +7% | +19% |
| YM-40 (1G) | .062 | .066 | +6% | .059 | +11% | -5% |
| YM-3 (1J) | .058 | .058 | 0 | .061 | +5% | +5% |
| YM-50 | .064 | .062 | -4% | | | |
| YM-56 | .082 | .077 | -4% | | | |

JDS

**ASARCO**

**Southwestern Exploration Division**

August 10, 1990

F.T. Graybeal
New York Office

M.A. Miller's Report
Meeting with Norgold
Yarnell Project
Yavapai County, AZ

I submit Miller's thoughts on the meeting with Norgold this past week.

James D. Sell

James D. Sell

JDS:mek
att.

cc: W.L. Kurtz (w/o att.)
S.L. Lakosky (w/att.)
L.J. Jansen (w/att.)

**ASARCO** Southwestern Exploration Division

August 9, 1990

J.D. Sell

Meeting with Norgold Res.
Yarnell Project
Yavapai County, Arizona

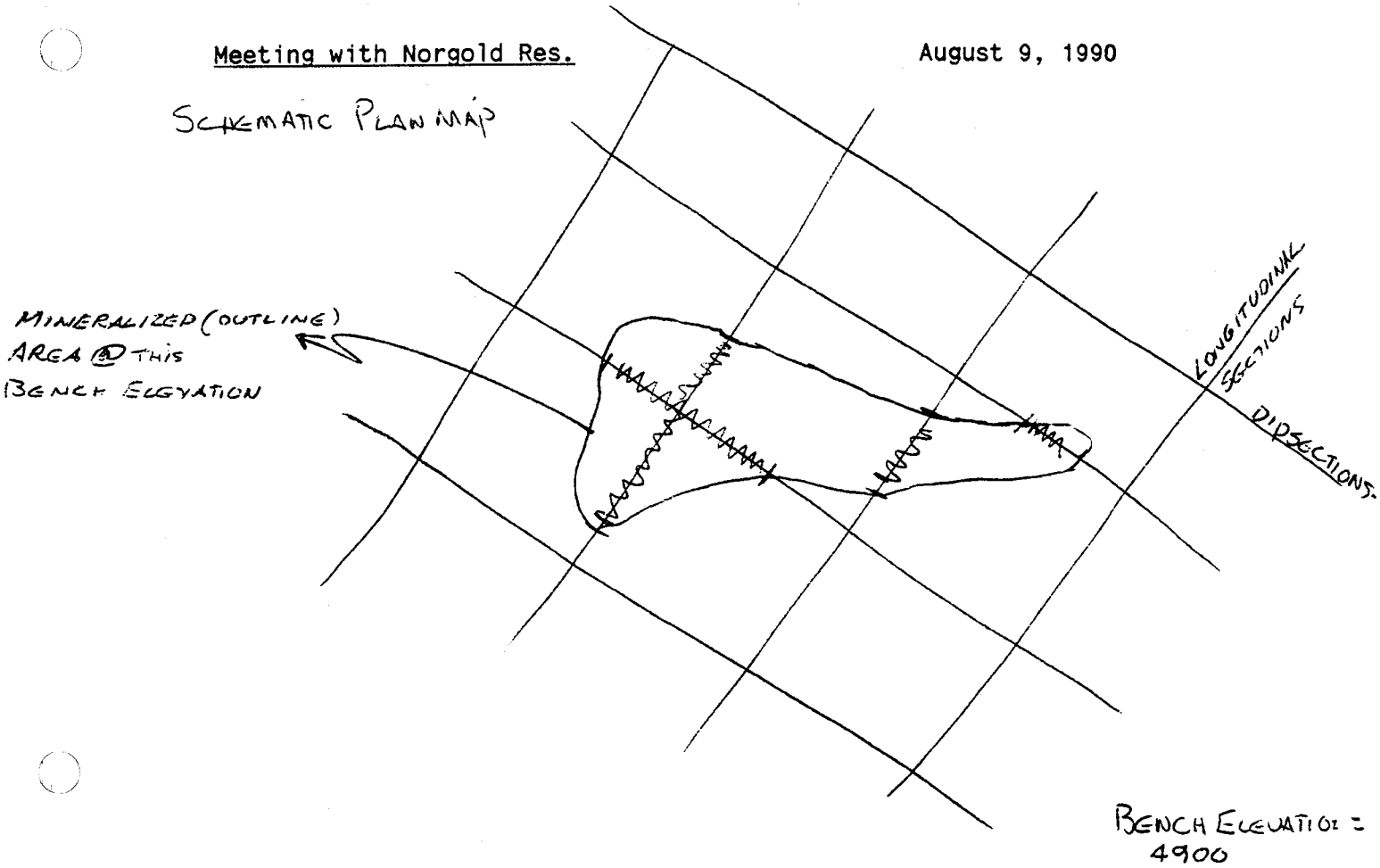
On August 8, 1990 I met with Steve Potter and Mike Philpot of Norgold Resources, and Robin Young of James Askew and Assoc. who is doing the reserves for Norgold. Young's ore reserve technique is very interactive, i.e., there is strong geologic control applied to the reserve methodology prior to reserve determination. The methodology is as follows:

1. Sections are plotted perpendicular to the Yarnell Fault on 100' centers. Holes are projected to the sections similar to what we have done with our sections. Overlapping holes are spaced on 50' centers so as to prevent the overlap (this creates 2 almost identical sections which will show the holes without overlap).

2. Sections are also plotted parallel to the strike of the Yarnell Fault (longitudinal sections) using the same series of parameters as outlined by #1.

3. The sections are then geologically interpreted. In their case, they have outlined on the dip and longitudinal sections the mineralized intervals with a .01 opt Au cutoff. This is predicated on separations >10' of less than .01 opt Au to break the vertical continuity of a zone. Using this technique, they have defined 3 and possibly 4 zones. These are sub zones of the A zone and the main B zone of Asarco. They have then contoured the base of these zones. One of the areas that they wanted to check today was the "upper altered zone" around the west adit. From the quick review that I saw, the mineral correlations appear to hang together. They emphasize, however, that these upper zones may or may not be ore (minable), but are definite mineral inventory. It appears to me that this technique better defines and refines the "A" zone of Asarco.

4. Once the boundary and correlation lines (the top and bottom of the mineral zones) are drawn on the dip and long sections, the sections are examined in plan to determine the influence of the mineralization at a certain elevation (bench elevation). The schematic diagram below will attempt to explain the technique.




What this technique does is constrain the mineral reserve since the limits are (or have been) determined by geologic/mineral boundaries. This also prevents the projection of blocks through computer projection (example, the projection of the ore blocks in the footwall of the Yarnell Fault on the SW side of the deposit). This technique also utilizes the plans and sections to determine the mineralized influence. Once the mineralized areas are drawn on the plan maps all of this data is (and continually has been) digitized and a reserve or mineral inventory is calculated. I am a little unclear as to the technique used here, but Robin Young says it uses variograms and confidence levels within the variogram. This technique can use any type of cutoff once all the data is digitized and will produce a <u>geologic</u> inventory, not a minable reserve.

5. To determine a minable reserve Robin Young uses a program called the Lerchs-Grossman 3-D optimizer which is a type of cone miner. The sections and all the digitizing are done through PC Explorer and PC Mine with modifications.

My impression on their technique is that unlike our reserves by ECS, this technique uses strong geologic input from the start. The computer is constrained to stay within the limits which geology dictates and by

using the two section directions (and more can be used) a three dimensional model is made. I think this is the way to go.

On a completely different note:

Norgold is "frustrated" by Asarco's "lack" of data sharing and has written a letter to Sy requesting certain data. I am sure you must have heard of their requests. Steve Potter does not feel that Asarco has enough basis and enough data to make a bankable feasibility study and on this note suggested in general discussion the following points and activities.

1. Mapping and sampling of the main workings.

2. Contract a structural geologist to determine the significance and importance of the various structural regimes. This should be done once 1 is completed.

3. More drilling which might be directed by using geostatistics on variograms. These holes would be within the drilled area and not as extensions as I have proposed in the past.

4. Check assays.

5. Investigation of the permitting process as to what will need to be done.

Norgold feels that the above points will be necessary for them to have completed in order for the lending institutions to accept the study as "Bankable." I claim ignorance in this regard.

Norgold's new management appears to be very agressive and I believe that they would "go at it alone" if we gave them the chance. I feel that a cooperative effort would be helpful, particularly in light of the reserve estimation and in light of small mine development. I think that Norgold will want to be a very active partner particularly with their new management.

Mark A. Miller

MAM:mek

cc: W.L. Kurtz

# ASARCO

**Exploration Department**
Southwestern United States Division

August 16, 1990

Mr. C.E. Thompson/Mr. W.L. Lehmbeck
Skyline Labs, Inc.
1775 W. Sahuaro Drive
Tucson, Arizona 85703

Yarnell Samples
Rick Schwarz Study

Gentlemen:

We have delivered to you four reject drill samples for evaluation by the Rick Schwarz scheme (per your attached flyer). Per discussion with Ed Post and Jim Sell, Asarco and Skyline will share the cost of the study. The four delivered samples are:

| | | Triad |
|---|---|---|
| YM-90 | - 145-150 | 0.044 |
| | 195-200 | 0.126 |
| | 200-205 | 0.298 |
| YM-88 | 245-250 | 0.050 |

These are the splitter rejects at the drill site and have not been through the assay lab.

Thank you for your help.

Respectfully,

Mark Miller

Mark A. Miller

MAM:mek

cc: J.D. Sell

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

J.D. Sell

MAM

# ASARCO

**Exploration Department**
Southwestern United States Division

August 16, 1990

Mr. C.E. Thompson/Mr. W.L. Lehmbeck
Skyline Labs, Inc.
1775 W. Sahuaro Drive
Tucson, Arizona 85703

Yarnell Samples
Rick Schwarz Study

Gentlemen:

We have delivered to you four reject drill samples for evaluation by the Rick Schwarz scheme (per your attached flyer). Per discussion with Ed Post and Jim Sell, Asarco and Skyline will share the cost of the study. The four delivered samples are:

| | | |
|---|---|---|
| YM-90 - | 145-150 | .044 |
| | 195-200 | .126 |
| | 200-205 | .298 |
| YM-88 | 245-250 | .050 |

These are the splitter rejects at the drill site and have not been through the assay lab.

Thank you for your help.

Respectfully,

Mark Miller

Mark A. Miller

MAM:mek

cc: J.D. Sell

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

Potters Letter 8/21/90

items 1-7

Steven C. Potter
210 475 Howe St.
Vancouver, BC Canada
V6C 2B3

Federal Express Today

not able to send
a remedy item
before 4 pm
this world
8/22/90
JOS

Ore Reserve Report.
Last Completion - Jansen.
Geotechnical.
JRS Resume.

Metallurgical Reports.

xerox on my part if needed.

52

JDS

# NORGOLD RESOURCES INC.

U.S. OFFICES:
13935 Chamy Drive
Reno, Nevada
89511
(702) 851-3177
Fax: (702) 851-3177

HEAD OFFICE:
210 - 475 Howe Street
Vancouver, B.C.
V6C 2B3
(604) 681-5566
Fax: (604) 687-8789

July 17, 1990

S.L.L.

JUL 23 1990

ASARCO Incorporated

AUG 21 1990

SW Exploration

Mr. S. L. Lakosky
Yarnell Project Manager
Asarco, Inc.
P. O. Box 5747
Tucson, Arizona 85703-0747

Dear Sy:

It was good to talk with you about the Yarnell project on June 15. We appreciate the progress Asarco has made at Yarnell and look forward to getting the property into production.

The purpose of this letter is to address Asarco's apparent reluctance to supply Norgold with certain additional information concerning the Yarnell project. We believe that Articles 7.1 and 12.3 of the Norgold/Asarco Exploration and Option Agreement, Section 9 of the Western Building and Mining Agreement and your fiduciary responsibility to Norgold make it appropriate that you provide us copies of all factual data and all substantive technical reports concerning the project. We respectfully request copies of the following information:

1. Final aerial survey topographic map. (We would be happy to reimburse you for the extra cost of a mylar.)
2. Coordinates, collar elevations, and assay and geologic logs for the four diamond drill holes.
3. Asarco's survey of the accessible underground workings.
4. Sample locations and assays for all surface sampling, including the sampling in the open cut. (We have the sample results from the trenching on the hill to the northeast of the presently defined deposit.)
5. Sample locations and assays for the underground sampling done by Asarco.
6. Information concerning the check assaying done by

Asarco.

7. All ore reserve reports.
8. All geotechnical reports.
9. All metallurgy reports.
10. All reports relating to obtaining a water supply. — No - to be discussed.
11. Any bids for performing contract mining or crushing.
12. The Kilborn engineering report.
13. Reports or correspondence concerning permitting requirements or on progress made to obtain the permits necessary to finance or construct mine facilities.
14. Monthly reports as required in Article 12.3(iii) of our Agreement.

Sy, I would appreciate your sending the above maps, data and reports to me at 368 Cameron Circle, San Ramon, CA 94583. If you have any questions, you can reach me at (415) 829-3451.

Sincerely yours,

Steven C. Potter

Steven C. Potter
President

cc: M. Philpot
B. Edgar

MIS-1.0

**ASARCO**

**MISSION UNIT**

July 23, 1990

ASARCO Incorporate

AUG 21 1990

SW Exploration

To: T. E. Scartaccini

From: S. L. Lakosky

Re: Yarnell Project

Attached is the letter Norgold's Steven Potter had promised about a month ago. Per my understanding of the Asarco/Norgold Agreement, we should supply the information Norgold recently requested in items #1 through #6. The Exploration Department should have all of the information, if you wish to have it sent. It is my opinion that we are not required to provide items #7 through #13 to Norgold. With regard to item #14, we should continue to provide monthly reports to Norgold. While there have been several months during which there was no new progress to report, the most recent report, dated July 2, 1990, covered the months of May and June, 1990.

S. L. Lakosky

S. L. Lakosky
Mine Superintendent
Mission Unit

SLL/lb

Attachment

FEDERAL EXPRESS

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

Copy

August 22, 1990

Mr. Steven C. Potter
Vice President
NORGOLD RESOURCES INC.
210-475 Howe Street
Vancouver, B.C.
Canada V6C 2BC

Yarnell Data

Dear Steve:

As requested by R.L. Brown and T.E. Scartaccini, I have collated a package containing or concerning the items mentioned in your July 17, 1990 letter to Mr. S.L. Lakosky. Items 1 thru 9 are individual submittals. Items 10 thru 13 are included in a new item 15 appended.

I trust the material will be satisfactory for the intended use.

Sincerely,

James D. Sell

JDS:mek
Attachments
1. List
2. Items

cc: R.L. Brown (with list of attachments only)
W.L. Kurtz ( " " " " " )
T.E. Scartaccini (with list of attachments only)

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

Copy

ATTACHMENT LIST

1. Final aerial survey topographic map, blackline print:
   a. Northern drilled area SW¼ Sec. 14, 1" = 100',
   b. Basic claim block area Sec. 14/23, 1" = 200'.
2. Coordinates, collar elevations, assay, geologic logs of diamond drill holes YDDH-1 thru -4.
3. Asarco's survey of the accessible underground workings.
4. Sample locations and assays for all surface sampling including the sampling in the open cut:
   a. Surface samples, other than listed below, on "Reconnaissance Geology, N and S sheets, 1" = 200' maps
   b. Open-cut sampling with location map, coordinates and assay values, 1" = 30'.
   c. Trench (Series Y-117), lower road (Series Y-128), lower road extension (Series Y-113), and upper road (Series Y-112); topo base 1" = 100'; also trench cross-section with assays 1" = 10'.
5. Sample locations and assays for the underground sampling done by Asarco. Note: Workings noted on Map 3.
   a. Underground main adit and cross-cut from main adit, 1"= 20',
   b. Fly adit, 1" = 20',
   c. West adit, 1" = 20'.
6. Information concerning the check assaying done by Asarco
   a. Portions of 23 rotary hole intervals, Triad vs. Skyline, July 15, 1989.
   b. Check sampling low grade zone in main tunnel, August 3, 1989,
   c. Original pulp vs. reject new pulp, YM-50, August 24, 1989.
   d. Rotary drill hole intervals vs. diamond core intervals, April 27, 1990.
   e. Original pulps vs. reject new pulp vs. refired new pulps, 10 rotary holes, August 10, 1990.
7. All ore reserve reports:
   a. Drill indicated reserve, J.D. Sell, December 20, 1989, with correction dated January 30, 1990.
   b. Computer-economic model reserve, L.J. Jansen, Feb. 9, 1990.
   c. See item 15 below.
8. All geotechnical reports. Note: No geotechnical reports.
9. All metallurgical reports:
   a. Final McClelland Metallurgical Report, March 19, 1990.
10. All reports related to obtaining a water supply:
    a. To be discussed.
       See item 15 below.
11. Any bids for performing contract mining or crushing. Note: See item 15 below.
12. The Kilborn engineering report. Note: See item 15 below.
13. Reports or correspondence concerning permitting requirements or on progress made to obtain the permits necessary to finance or construct mine facilities. Note: See item 15 below.
14. Monthly reports as required in Article 12.3 (iii) of our Agreement. Note: Monthly report submitted.
15. (Not on list of July 17, 1990)
    a. Memorandum of Yarnell Project intermediate Feasibility Study, S.L. Lakosky, February 16, 1990.

JDS

FROM: J. D. SELL

TO: MHM

Corrected
Original Pug Assay vs
Reject new Pulp Assay
of Aug 10, 1990

1) YM-12
only 80' of composite
not 90'
185-195 missing, i.e. 90-10=80

2) in YM-40 you should have
placed 345-350 ; 350-355
up in the proper sequence.

(over)

3) Why wasn't YM-3 listed
1st in the sequence?

4) in Table 2
~~YM-1~~ See me
has + & - mixed up.

JDS

CERTIFIED MAIL
RETURN RECEIPT

# ASARCO

**Exploration Department**
Southwestern United States Division

August 21, 1990

Ms. Patsy Jenney-Colon, Recorder
Administration Building
255 East Gurley St.
Prescott, AZ 86301

Dear Ms. Jenney-Colon:

Enclosed is an amended notice of location to be recorded. After recording please send four (4) certified copies to:

W.D. Gay, Land Engineer
ASARCO Incorporated
P.O. Box 5747
Tucson, AZ 85703

Enclosed:

1. $10.00 to record document
   20.00 for four (4) certified copies

   $30.00 Total

2. Self addressed envelope for return of certified copies and the recorded document.

Very truly yours,

W. D. Gay
W.D. Gay
Land Engineer, SWED

WDG:mek
Encs.

cc: J.D. Sell
W.L. Kurtz
M.A. Miller
C.L. Snow

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

AMENDED NOTICE OF LOCATION
(Lode Claim)

Notice is hereby given that Western Building and Mining Co., Inc. whose mailing address is P.O. Box 4006, Reading, PA 19606 by its undersigned agent, makes this location of the PENNSYLVANIA No. 1 lode mining claim, in WEAVER Mining District, County of YAVAPAI, State of Arizona.

The claim is 1465 feet± in length along the vein or deposit of mineral bearing rock in place and 600 feet or less in width ( 300 feet or less on either side of the center line of the claim), forming a claim in the shape of a parallelogram. The general course of said claim is NE

This Notice is posted on the centerline of the claim which location monument is in Section 14, Township 10N, Range 5W, GSRM.

The location monument of said claim is located approx. N06°W, 1297'± from the SW corner of Section 14, Township 10N, Range 5W, GSRM, Arizona and said claim lies within the SW 1/4 SEC. 14 & SE 1/4 SEC 15, T.10N, R.5W. GSRM.

The surface boundaries of the claim are described as follows: Beginning at the discovery monument and running thence N66°E 895'± to the center of the east end line and the true point of beginning thence (clockwise) S43°E, 310'± to corner 1 thence S66°W, 1495'± to corner 2 thence N43°W, 310'± to center west end line, thence N43°W, 310'± to corner 3, thence N66°E, 1465'± to corner 4, thence S43°E, 310'± to the point of beginning.

There are seven substantial posts, projecting at least 4 feet above the surface of the ground, or stone monuments, at least 3 feet high, one for the location monument, one at each of the four corners and one at the center of each end line as prescribed by A.R.S. §27-204.

Located, dated and posted on the ground this 22ND day of AUGUST, 1990.

The original Notice of Location of this claim is recorded in the official records of YAVAPAI County, Arizona, as follows:

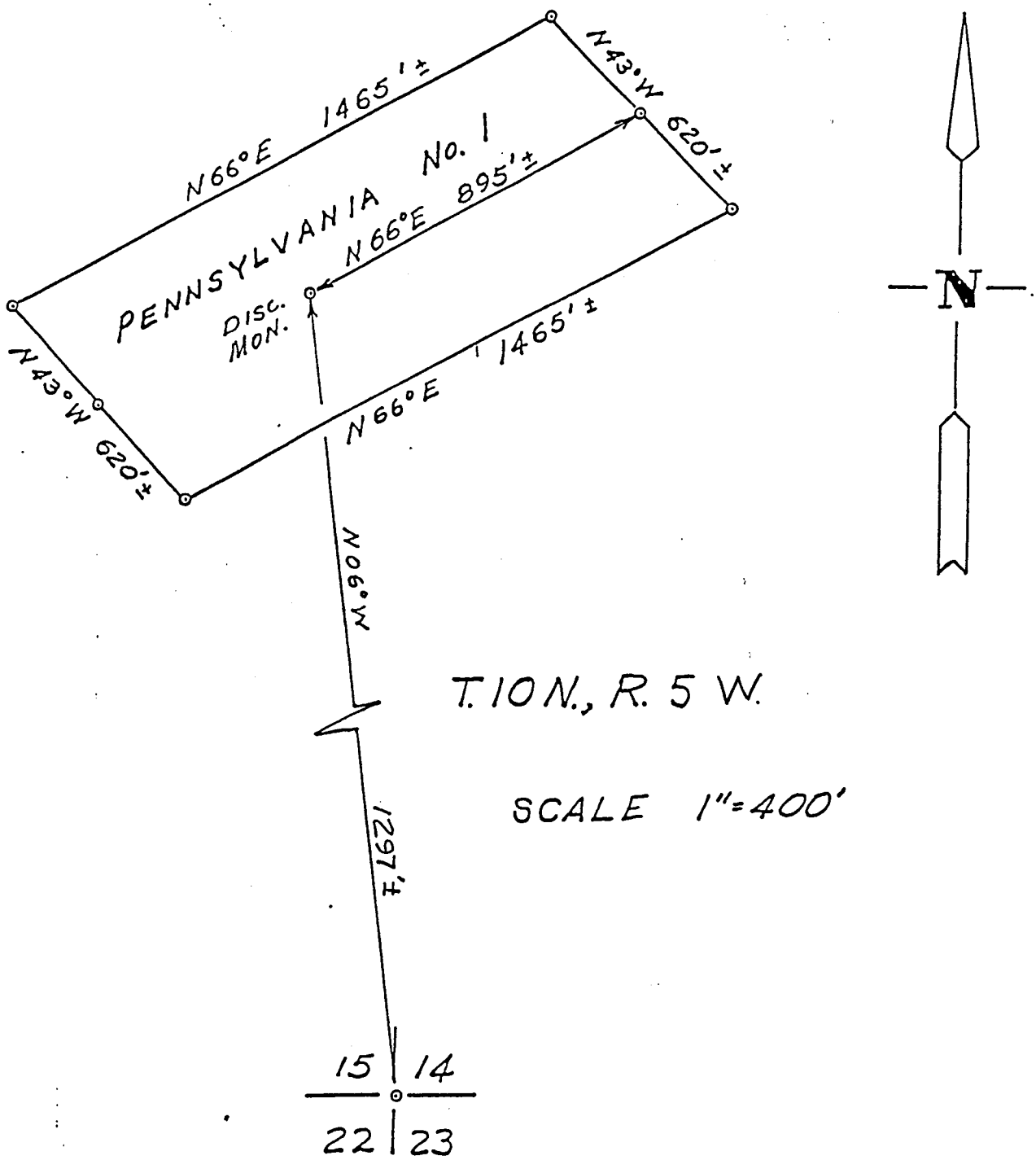
| DATE RECORDED | BOOK | PAGE | BLM SERIAL NO. |
|---|---|---|---|
| JUNE 30, 1981 | 1392 | 661 | AMC 134462 |
| AMENDED NOTICE AS FOLLOWS: | | | |
| JULY 17, 1990 | 2270 | 319 | |

This amendment is made for purposes of more accurately describing the boundaries hereof and correcting errors or omissions (if any) contained in the original location notice. This amendment is made without waiver of the rights previously acquired under the location hereof. If for any reason it is determined that this notice is ineffective as an amendment of the location of this claim, the undersigned intends that this amendment shall serve as an original location of the area described herein as of the date of posting hereof.

Western Building and Mining Co., Inc.

BY William D. Gay
ASARCO Incorporated
William D. Gay, Agent

# PENNSYLVANIA No. 1 (AMENDED)



# ASARCO

**Exploration Department**
Southwestern United States Division

CERTIFIED MAIL
RETURN RECEIPT

July 20, 1990

Bureau of Land Management
Arizona State Office
Mining Claims Section
P.O. Box 16563
Phoenix, AZ 85011

Amended Notice of Location
Pennsylvania No. 1 Lode Claim
Weaver Mining District
Yavapai County, Arizona

Gentlemen:

In accordance with Section 314 of the Federal Land Policy and Management Act of 1976, enclosed is the following Amended Notice of Location with map as recorded in Yavapai County, Arizona.

| Name of Claim | Date of Location | Date of Amend.Loc. | Recorded Book | Recorded Page | BLM Serial Number |
|---|---|---|---|---|---|
| Pennsylvania No. 1 | 6/30/81 | 7/17/90 | 2270 | 319 | AMC 134462 |

Asarco's check of $5.00 as your filing fee, and a stamped return envelope for your receipt and accounting advise are also enclosed.

Very truly yours,

William D. Gay

William D. Gay
Land Engineer, SWED

WDG:mek
encs.

cc: J.D. Sell
C.L. Snow
R.L. Brown

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

P.O. Box 5747
TUCSON, AZ 85703

AMENDED NOTICE OF LOCATION
(Lode Claim)

**RUSH**

Notice is hereby given that Western Building and Mining Co., Inc. whose mailing address is P.O. Box 4006, Reading, PA 19606 by its undersigned agent, makes this location of the PENNSYLVANIA No. 1 lode mining claim, in WEAVER Mining District, County of YAVAPAI, State of Arizona.

The claim is 1465 feet± in length along the vein or deposit of mineral bearing rock in place and 600 feet or less in width ( 300 feet or less on either side of the center line of the claim), forming a claim in the shape of a parallelogram. The general course of said claim is NE

This Notice is posted on the centerline of the claim which location monument is in Section 14, Township 10N, Range 5E, GSRM.

The location monument of said claim is located approx. N06°W, 1297'± from the SW corner of Section 14, Township 10N, Range 5E, GSRM, Arizona and said claim lies within the SW 1/4 SEC. 14 & SE 1/4 SEC 15, T.10N, R.5E GSRM.

The surface boundaries of the claim are described as follows: Beginning at the discovery monument and running thence N66°E 895'± to the center of the east end line and the true point of beginning thence (clockwise) S43°E, 310'± to corner 1 thence S66°W, 1495'± to corner 2 thence N43°W, 310'± to center west end line, thence N43°W, 310'± to corner 3, thence N66°E, 1465'± to corner 4, thence S43°E, 310'± to the point of beginning.

There are seven substantial posts, projecting at least 4 feet above the surface of the ground, or stone monuments, at least 3 feet high, one for the location monument, one at each of the four corners and one at the center of each end line as prescribed by A.R.S. §27-204.

Located, dated and posted on the ground this 17TH day of JULY, 1990.

The original Notice of Location of this claim is recorded in the official records of YAVAPAI County, Arizona, as follows:

| DATE RECORDED | BOOK | PAGE | BLM SERIAL NO. |
|---|---|---|---|
| JUNE 30, 1981 | 1392 | 661 | AMC 134462 |

This amendment is made for purposes of more accurately describing the boundaries hereof and correcting errors or omissions (if any) contained in the original location notice. This amendment is made without waiver of the rights previously acquired under the location hereof. If for any reason it is determined that this notice is ineffective as an amendment of the location of this claim, the undersigned intends that this amendment shall serve as an original location of the area described herein as of the date of posting hereof.

Western Building and Mining Co., Inc.

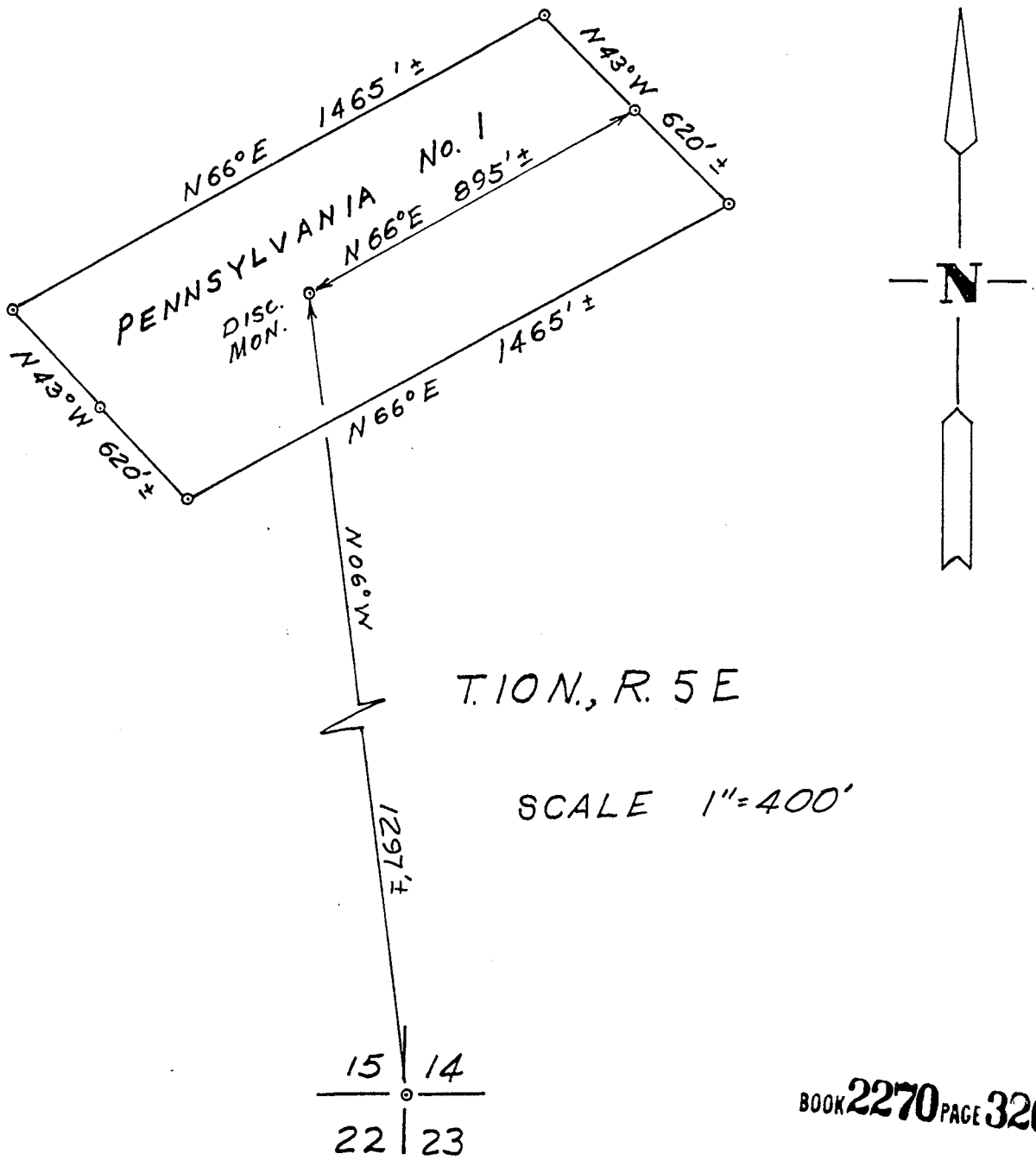
INSTRUMENT # 9027337
OFFICIAL RECORDS OF
YAVAPAI COUNTY
PATSY C. JENNEY
REQUEST OF:
WILLIAM D GAY
DATE: 07/17/90 TIME: 14:30
FEE: 5.00 SC: 4.00 PT: 1.00
BOOK 2270 PAGE 319 PAGES: 002

INDEXED &
MICROFILMED

BY William D. Gay
ASARCO Incorporated
William D. Gay, Agent

BOOK 2270 PAGE 319

# PENNSYLVANIA No. 1 (AMENDED)




BOOK 2270 PAGE 320

FEDERAL EXPRESS

JDS

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

August 22, 1990

Mr. Steven C. Potter
Vice President
NORGOLD RESOURCES INC.
210-475 Howe Street
Vancouver, B.C.
Canada V6C 2B3 ph. 604/681-5566
FAX 604/687-8789

Yarnell Data

Dear Steve:

As requested by R.L. Brown and T.E. Scartaccini, I have collated a package containing or concerning the items mentioned in your July 17, 1990 letter to Mr. S.L. Lakosky. Items 1 thru 9 are individual submittals. Items 10 thru 13 are included in a new item 15 appended.

I trust the material will be satisfactory for the intended use.

Sincerely,

James D. Sell

James D. Sell

JDS:mek
Attachments
1. List
2. Items

cc: R.L. Brown (with list of attachments only)
W.L. Kurtz ( " " " " " )
T.E. Scartaccini (with list of attachments only)

# ATTACHMENT LIST

1. Final aerial survey topographic map, blackline print
   a. Northern drilled area SW¼ Sec. 14, 1" = 100'
   b. Basic claim block area Sec. 14/23, 1" = 200'.
2. Coordinates, collar elevations, assay, geologic logs of diamond drill holes YDDH-1 thru -4.
3. Asarco's survey of the accessible underground workings.
4. Sample locations and assays for all surface sampling including the sampling in the open cut
   a. Surface samples, other than listed below, on "Reconnaissance Geology, N and S sheets, 1" = 200' maps
   b. Open-cut sampling with location map, coordinates and assay values, 1" = 30'
   c. Trench (Series Y-117), lower road (Series Y-128), lower road extension (Series Y-113), and upper road (Series Y-112); topo base 1" = 100'; also trench cross-section with assays 1" = 10'.
5. Sample locations and assays for the underground sampling done by Asarco. Note: Workings noted on Map 3.
   a. Underground main adit and cross-cut from main adit, 1"= 20'
   b. Fly adit, 1" = 20'
   c. West adit, 1" = 20'.
6. Information concerning the check assaying done by Asarco
   a. Portions of 23 rotary hole intervals, Triad vs. Skyline, July 15, 1989
   b. Check sampling low grade zone in main tunnel, August 3, 1989
   c. Original pulp vs. reject new pulp, YM-50, August 24, 1989
   d. Rotary drill hole intervals vs. diamond core intervals, April 27, 1990
   e. Original pulps vs. reject new pulp vs. refired new pulps, 10 rotary holes, August 10, 1990.
7. All ore reserve reports
   a. Drill indicated reserve, J.D. Sell, December 20, 1989, with correction dated January 30, 1990
   b. Computer-economic model reserve, L.J. Jansen, Feb. 9, 1990
   c. See item 15 below.
8. All geotechnical reports. Note: No geotechnical reports.
9. All metallurgical reports
   a. Final McClelland Metallurgical Report, March 19, 1990.
10. All reports related to obtaining a water supply
    a. To be discussed.
       See item 15 below.
11. Any bids for performing contract mining or crushing.
    Note: See item 15 below.
12. The Kilborn engineering report. Note: See item 15 below.
13. Reports or correspondence concerning permitting requirements or on progress made to obtain the permits necessary to finance or construct mine facilities. Note: See item 15 below.
14. Monthly reports as required in Article 12.3 (iii) of our Agreement.
    Note: Monthly report submitted.
15. (Not on list of July 17, 1990)
    a. Memorandum of Yarnell Project intermediate Feasibility Study, S.L. Lakosky, February 16, 1990.

JDS

AUGUST 28, 1990

AUG 2 9 1990

SW Exploration

GEORGE MYERS

ASSESSEMENT WORK
YARNELL CLAIMS

ATTACHED ARE COPIES OF PAPER WORK FOR ASSESSEMENT WORK DONE BY SWED LAST YEAR.

ALL DATA IS THE SAME FOR THIS YEAR EXCEPT:

1) UNIVERSAL DRILLING DID NOT DO ANY WORK
2) ADD CLAIM BLACK DIKE No. 3
   A MC 72445 BOOK 153 PAGE 393

~~3) INFO~~

INFORMATION FOR THE STATE MINING CLAIM (KACHINA DOLL — STATE LEASE NO. 11-31009) ~~CAN BE OBTAINED~~ FROM MARK MILLER (BLANK ATTACHED).

FOR THE RECORD A CONFLICT EXISTS BETWEEN CLAIMS YX-2, YAR-7 AND YAR-39 AND IF DON JENKINS DOES NOT FILE AN AFFIDAVIT OF ASSESSMENT WORK ON HIS YX-2 CLAIM THIS YEAR, THEN YAR-39 CAN BE DROPPED NEXT YEAR AND YAR-7 WILL BE THE SURVIVING CLAIM. I WILL LET YOU KNOW THE STATUS OF YX-2 AFTER DEC. 30, 1990

c.c.: J.D.S. w/o attach.

W. D. Gary

JDS

# ASARCO

Exploration Department
R. L. Brown
Vice President

August 28, 1990

DELIVERED BY HAND

Norgold Resources, Inc.
Suite 206 - 475 Howe Street
Vancouver, British Columbia
V6C 2B3 CANADA

ASARCO Inc.
SEP 11 1990
SW Exploration

Dear Sirs:

Pursuant to the Exploration and Option Agreement effective as of January 30, 1989 between ASARCO Incorporated and Norgold Resources (US) Inc., this provides notice to you that Asarco hereby terminates that Agreement.

You are aware that, prior to the date of our Agreement, there existed on the property certain adits, cuts, dumps and other workings from prior mining activities. Please be advised that, during the course of the Agreement, Asarco did not disrupt, modify, or affect any existing mine working or opening in any manner. Further, our activities did not create or uncover any additional or new workings.

We regret that we were unable to identify a resource sufficient for our purposes.

Yours very truly,

R. L. Brown

R. L. Brown

RLB:mc

cc: B. D. Edgar, Esq.
C. S. Moat

bcc: W. Dowd
T. E. Scartaccini
J. D. Sell

cc: W.L. Kurtz
W.D. Gay
C.L. Snow
(9/11/90)

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

JDS

New York, September 7, 1990

ASARCO Incorp
SEP 12 1990
SW Exploration

CONFIDENTIAL

MEMORANDUM FOR Exploration Supervisors

Yesterday we terminated the Yarnell Agreement for a number of good reasons, some of which may be summarized as follows:

- The estimated ROI indicated even during the early going before we know that water acquisition, permitting and reclamation cost would be way high was marginal, and creative financing such as low interest gold loans would have been required to make the project even marginally attractive. After these costs became evident the estimated ROI was nil.

- It would be advantageous to Asarco to own ounces of gold in the ground and to be seen as a significant producer of gold, and we might take on a ROI marginal project as a result. However, Yarnell would have produced 37,000 ounces of gold a year, and for only 4 years and, therefore, would not have added significantly either to our ore reserves or to gold production totals, or to the public perception of Asarco as a gold producer.

- Yarnell ore reserves were determined at a 3-1 waste ore ratio. A higher mineral inventory could have been drilled, but waste ore ratio were such that we could have added to ore reserves only at gold prices far higher than any now forecast by anyone. The obvious result of this is that the financial upside of a project there is limited or at best highly suspect. The downside is ripe with adverse possibilities. Indications were that permitting would have been expensive, but there is no way of predicting with precision how expensive. A one million dollar swing in permitting or any cost can wreck a ROI on a Yarnell-sized project.

- Uncertainty in required reclamation costs aggravated by the proximity of the project to both the village of Yarnell and Highway 78 was a severe problem. It is obvious that the prospect of not marking much money combined with the possibility of difficult media attention (impacting on Ray, Mission and Hayden) was a serious and obvious deterrent.

The mining gossip press already has speculated that we will drop out of Yarnell because it is too small. That speculation is dead wrong and I am concerned some of our people might be listening to the wrong signal. We dropped out of Yarnell not because it is too small, but because we did not think we could make enough money there to cover obvious risks.

Same they're not enough to pay

Our objectives and criteria have not changed. We will explore small deposits, and when the geometry, tonnages and grade of such deposits conspire together to indicate good profits we will mine them, bearing in mind that the smaller the deposit, the better the required ROI. Please note the above as a reiteration of many previous statements of mine on this subject.

Our current practice is to butt our heads doggedly against obvious permitting problems which might get worse if permitting a mining operation is attempted. We may reconsider this policy, but again only on a case-by-case basis. In the meanwhile, please do not read anything into our Yarnell experience that is not there.

R. L. Brown

R. L. Brown

RLB:mc

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

CERTIFIED MAIL
RETURN RECEIPT

August 28, 1990

Bureau of Land Management
Arizona State Office
Mining Claims Section
P.O. Box 16563
Phoenix, AZ 85011

Amended Notice of Location
Pennsylvania No. 1 Claim
Weaver Mining District
Yavapai County, AZ

Gentlemen:

In accordance with Section 314 of the Federal Land Policy and Management Act of 1976, enclosed is an Amended Notice of Location with map as recorded in Yavapai County, Arizona.

| Name of Claim | Date of Location | Date of Amend.Loc. | Recorded Book | Recorded Page | BLM Serial Number |
|---|---|---|---|---|---|
| Pennsylvania No. 1 | 6/30/81 | 8/22/90 | 2281 | 357-358 | AMC 134462 |

Asarco's check of $5.00 as your filing fee and a stamped return envelope for your receipt and accounting advice are also enclosed.

Very truly yours,

William D. Gay

William D. Gay
Land Engineer, SWED

WDG:mek
enc.

cc: J.D. Sell
W.L. Kurtz
M.A. Miller
C.L. Snow

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

AMENDED NOTICE OF LOCATION
(Lode Claim)

**RUSH**

Notice is hereby given that Western Building and Mining Co., Inc. whose mailing address is P.O. Box 4006, Reading, PA 19606 by its undersigned agent, makes this location of the PENNSYLVANIA No. 1 lode mining claim, in WEAVER Mining District, County of YAVAPAI, State of Arizona.

The claim is 1465 feet± in length along the vein or deposit of mineral bearing rock in place and 600 feet or less in width ( 300 feet or less on either side of the center line of the claim), forming a claim in the shape of a parallelogram. The general course of said claim is NE

This Notice is posted on the centerline of the claim which location monument is in Section 14, Township 10N, Range 5W, GSRM.

The location monument of said claim is located approx. N06°W, 1297'± from the SW corner of Section 14, Township 10N, Range 5W, GSRM, Arizona and said claim lies within the SW 1/4 SEC. 14 & SE 1/4 SEC 15, T.10N, R.5W GSRM.

The surface boundaries of the claim are described as follows: Beginning at the discovery monument and running thence N66°E 895'±. to the center of the east end line and the true point of beginning thence (clockwise) S43°E, 310'± to corner 1 thence S66°W, 1495'± to corner 2 thence N43°W, 310'± to center west end line, thence N43°W, 310'± to corner 3, thence N66°E, 1465'± to corner 4, thence S43°E, 310'± to the point of beginning.

There are seven substantial posts, projecting at least 4 feet above the surface of the ground, or stone monuments, at least 3 feet high, one for the location monument, one at each of the four corners and one at the center of each end line as prescribed by A.R.S. §27-204.

Located, dated and posted on the ground this 22ND day of AUGUST, 1990.

The original Notice of Location of this claim is recorded in the official records of YAVAPAI County, Arizona, as follows:

| DATE RECORDED | BOOK | PAGE | BLM SERIAL NO. |
|---|---|---|---|
| JUNE 30, 1981 | 1392 | 661 | AMC 134462 |
| AMENDED NOTICE AS FOLLOWS: | | | |
| JULY 17, 1990 | 2270 | 319 | |

This amendment is made for purposes of more accurately describing the boundaries hereof and correcting errors or omissions (if any) contained in the original location notice. This amendment is made without waiver of the rights previously acquired under the location hereof. If for any reason it is determined that this notice is ineffective as an amendment of the location of this claim, the undersigned intends that this amendment shall serve as an original location of the area described herein as of the date of posting hereof.

Western Building and Mining Co., Inc.

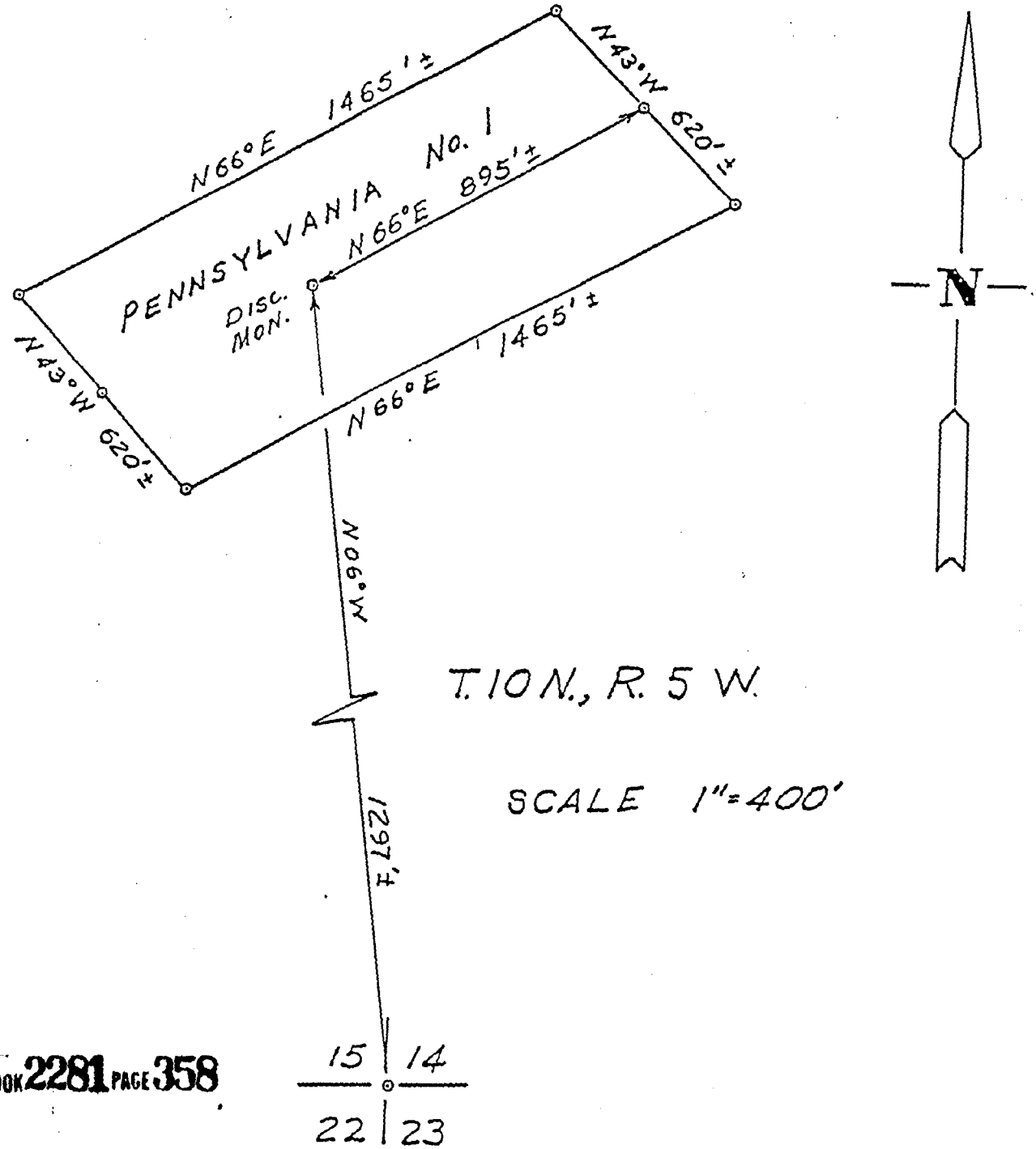
BY William D. Gay
ASARCO Incorporated
William D. Gay, Agent

BOOK 2281 PAGE 357

RECORDER YAVAPAI COUNTY ARIZONA
INSTRUMENT # 9032306
OFFICIAL RECORDS OF
YAVAPAI COUNTY
PATSY C. JENNEY
REQUEST OF:
ASARCO
DATE: 08/23/90 TIME: 10:00
FEE: 5.00 SC: 4.00 PT:
BOOK 2281 PAGE 357 PAGES: 002

INDEXED & MICROFILMED

# PENNSYLVANIA No. 1 (AMENDED)




BOOK 2281 PAGE 358

Form 1370-41
(March 1984)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

T.E.S.

SEP 4 1990

# RECEIPT AND ACCOUNTING ADVICE

NO. 1641803 04

SM/AZ 08/29/90

Subject:

AMENDMENTS (1) 2 10 12 5.00

Applicant:

ASARCO INCORPORATED
P. O. BOX 5747
TUCSON, AZ 85703-0747

Remitter: SAME - CK #03660
792-3010

Assignor:

| SERIAL NO. |
|---|
| AMC 134462 PENNSYLVANIA #1 |

*REFER TO THE ABOVE CASE SERIAL NUMBER IN ALL CORRESPONDENCE. PLEASE INFORM THIS OFFICE OF ANY CHANGE IN ADDRESS.*

NOTE: This notice is a receipt for monies paid the United States. If these monies are for required fees in connection with your application to lease, purchase, enter, or otherwise acquire an interest in public lands or resources, this receipt is not an authorization to utilize the land applied for and it does not convey any right, title, or interest in the land for which application is made.

ASARCO Incorporated
SEP 4 1990
SW Exploration

cc: J.D. Sell
M.A. Miller
W.D. Gay
C.L. Snow

SW MINING DEPT.
AUG 31 1990
TUCSON

RECEIPT

**ASARCO**

**Southwestern Exploration Division**

August 30, 1990

W.D. Gay

1989-90 Assessment
Yarnell Project
Yavapai County, AZ

Asarco has spent in excess of $100,000 on its claims within the Yarnell J.V. area. This satisfies our assessment requirements for these claims.

MAM:mek

Mark A. Miller
Project Geologist

cc: J.D. Sell
G.H. Myers

# ASARCO

**Exploration Department**
Southwestern United States Division

September 4, 1990

Mr. Steve Potter, President
NORGOLD RESOURCES INC.
210-475 Howe Street
Vancouver, B.C. V6C-2B3
Canada

YM-90 Rechecks
Yarnell Project
Yavapai County, AZ

Dear Steve:

Attached are the equivalent check intervals to YM-40. I hope this meets your needs.

Respectfully,

Mark A. Miller

MAM:mek

cc: J.D. Sell

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

# RECHECKS OF (B ZONE) ORE INTERVALS

## SELECTED HOLES

## YARNELL PROJECT

| NEW HOLE | FOOTAGE | ORIGINAL HOLE | FOOTAGE |
|---|---|---|---|
| 1D | 0 - 5 | YM 12A | 150 - 155 |
| | 5 - 10 | | 155 - 160 |
| | 10 - 15 | | 160 - 165 |
| | 15 - 20 | | 165 - 170 |
| | 20 - 25 | | 170 - 175 |
| | 25 - 30 | | 175 - 180 |
| | 30 - 35 | | 180 - 185 |
| | | | 185 - 190 No Sample Sto |
| | | | 190 - 195 " " " |
| | | | 195 - 200 Bad Rtn. sma |
| | 50 - 55 | | 200 - 205 |
| | 55 - 60 | | 205 - 210 |
| | 60 - 65 | | 210 - 215 |
| | 65 - 70 | | 215 - 220 |
| | 70 - 75 | | 220 - 225 |
| | 75 - 80 | | 225 - 230 |
| | 80 - 85 | | 230 - 235 |
| | 85 - 90 | | 235 - 240 |
| 1E | Same No.'s | YM 20A | Same No.'s |
| 1F | 0 - 5 | YM 24A | 75 - 80 |
| | 5 - 10 | | 80 - 85 |
| | 10 - 15 | | 85 - 90 |
| | 15 - 20 | | 90 - 95 |
| | 20 - 25 | | 95 - 100 |
| | 25 - 30 | | 100 - 105 |
| | 30 - 35 | | 105 - 110 |
| | 35 - 40 | | 110 - 115 |
| 1G | 0 - 5 | YM 40A | 275 - 280 |
| | 5 - 10 | | 280 - 285 |
| | 10 - 15 | | 285 - 290 |
| | 15 - 20 | | 290 - 295 |
| | 20 - 25 | | 295 - 300 |
| | 25 - 30 | | 300 - 305 |
| | 30 - 35 | | 305 - 310 |
| | 35 - 40 | | 310 - 315 |
| | 40 - 45 | | 315 - 320 |
| | 45 - 50 | | 320 - 325 |
| | 50 - 55 | | 325 - 330 |
| | 55 - 60 | | 330 - 335 |
| | 60 - 65 | | 335 - 340 |
| | 65 - 70 | | 340 - 345 |
| | 70 - 75 | | 355 - 360 |
| | 75 - 80 | | 360 - 365 |

# RECHECKS OF (B ZONE) ORE INTERVALS

## SELECTED HOLES

## YARNELL PROJECT

| NEW HOLE | FOOTAGE | ORIGINAL HOLE | FOOTAGE |
|---|---|---|---|
| 1G | 80 - 85 | YM 40A | 365 - 370 |
| | 85 - 90 | | 370 - 275 |
| | 90 - 95 | | 375 - 380 |
| | 95 - 100 | | 345 - 350 Pulps only |
| | 100 - 105 | | 350 - 355 " " |
| 1J | 0 - 5 | YM 3A | 130 - 135 |
| | 5 - 10 | | 135 - 140 |
| | 10 - 15 | | 140 - 145 |
| | | | 145 - 160 Missing Stop |
| | 15 - 20 | | 160 - 165 |
| | 20 - 25 | | 165 - 170 |
| | 25 - 30 | | 170 - 175 |
| | 30 - 35 | | 175 - 180 |
| | 35 - 40 | | 180 - 185 |
| | 40 - 45 | | 185 - 190 |
| | 45 - 50 | | 190 - 195 |
| | 50 - 55 | | 195 - 200 |
| | 55 - 60 | | 200 - 205 |

**McLAIN HARBERS CO., INC.**
AERIAL MAPPING & SURVEYING
720 W. Prince Rd.
Tucson, Arizona 85705

PHONE (602) 887-7272

September 5, 1990

Mr. Bill Gay
Asarco
1150 N. 7th Ave.
Tucson, AZ 85705

RE: YARNELL MINERAL SURVEY

Dear Mr. Gay;

Our fee for the Mineral Survey will be approximately $4000.00. This includes the preliminary and final survey, also BLM approval.

Should you have any questions, please let me know.

Sincerely,

Gordon McLain

Gordon McLain

cc: J.D. Sell
9/10/90

ASARCO Inc.

SEP 1 0 1990

SW Exploration

# ASARCO

**Exploration Department**
Southwestern United States Division

September 6, 1990

Mr. James P. Kelly
Chief, Branch of Cadastral Survey
U.S. Department of the Interior
Bureau of Land Management
P.O. Box 16563
Phoenix, AZ 85011

Dear Sir:

On July 31, 1990 you issued an order for Mineral Survey No. 4876 to Mr. Gordon W. McLain (copy of your letter is attached).

It was discovered the amended location dated July 17, 1990 showed Range 5 East, but should have been Range 5 West. This was corrected. Enclosed is an uncertified copy of the amended location notice and a certified copy of the amended location notice.

If you have any questions, please call me at (602) 792-3010.

Very truly yours,

William D. Gay

William D. Gay
Land Engineer, SWED

WDG:mek
encs.

cc: W.L. Kurtz
J.D. Sell
M.A. Miller

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

AMENDED NOTICE OF LOCATION
(Lode Claim)

Notice is hereby given that Western Building and Mining Co., Inc. whose mailin address is P.O. Box 4006, Reading, PA 19606 by its undersigned agent, makes this location of the PENNSYLVANIA No. 1 lode mining claim, in WEAVER Mining District, County of YAVAPAI, State of Arizona.

The claim is 1465 feet± in length along the vein or deposit of mineral bearing rock in place and 600 feet or less in width ( 300 feet or less on either side of the center line of the claim), forming a claim in the shape of a parallelogram. The general course of said claim is NE

This Notice is posted on the centerline of the claim which location monument is in Section 14, Township 10N, Range 5W, GSRM.

The location monument of said claim is located approx. N06°W 1297'± from the SW corner of Section 14, Township 10N, Range 5W, GSRM, Arizona and said claim lies within the SW 1/4 SEC 14 & SE 1/4 SEC 15, T10N, R5W GSRM.

The surface boundaries of the claim are described as follows: Beginning at the discovery monument and running thence N66°E 895'± to the center of the east end line and the true point of beginning thence (clockwise) S43°E, 310'± to corner 1 thence S66°W, 1495'± to corner 2 thence N43°W, 310'± to center west end line, thence N43°W, 310'± to corner 3, thence N66°E, 1465'± to corner 4, thence S43°E, 310'± to the point of beginning.

There are seven substantial posts, projecting at least 4 feet above the surface of the ground, or stone monuments, at least 3 feet high, one for the location monument, one at each of the four corners and one at the center of each end line as prescribed by A.R.S. §27-204.

Located, dated and posted on the ground this 22ND day of AUGUST, 1990.

The original Notice of Location of this claim is recorded in the official records of YAVAPAI County, Arizona, as follows:

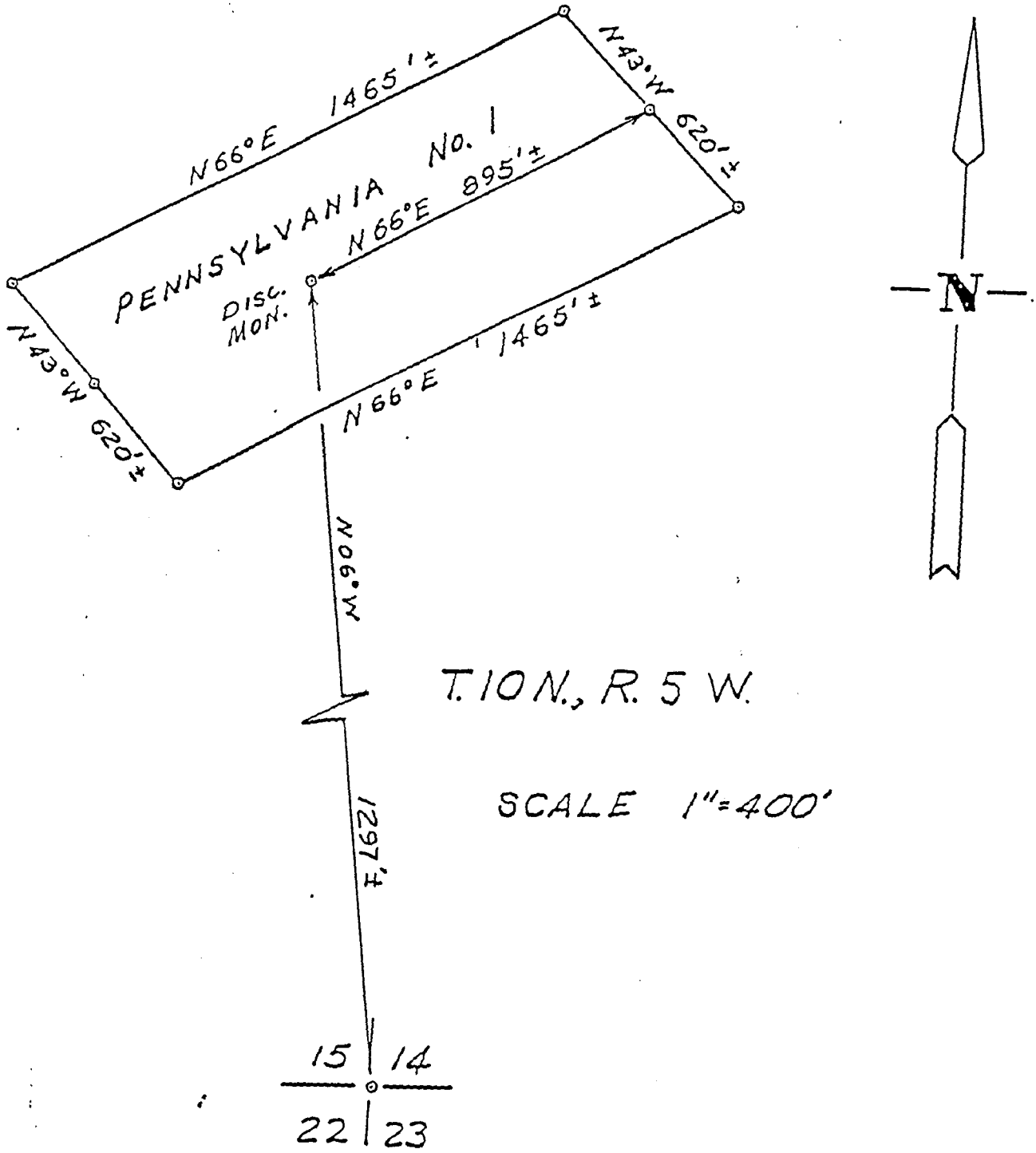
| DATE RECORDED | BOOK | PAGE | BLM SERIAL NO. |
|---|---|---|---|
| JUNE 30, 1981 | 1392 | 661 | AMC 134462 |
| AMENDED NOTICE AS FOLLOWS: | | | |
| JULY 17, 1990 | 2270 | 319 | |

This amendment is made for purposes of more accurately describing the boundaries hereof and correcting errors or omissions (if any) contained in the original location notice. This amendment is made without waiver of the rights previously acquired under the location hereof. If for any reason it is determined that this notice is ineffective as an amendment of the location of this claim, the undersigned intends that this amendment shall serve as an original location of the area described herein as of the date of posting hereof.

Western Building and Mining Co., Inc

BY William D. Gay
ASARCO Incorporated
William D. Gay, Agent

# PENNSYLVANIA No. 1 (AMENDED)



Form 1370-41
(March 1984)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

T.E.S.

SEP 4 1990

# RECEIPT AND ACCOUNTING ADVICE

NO. 1641803 04

Subject: AMENDMENTS (1)

SM/AZ 08/29/90

2 10 12: 5.00

Applicant:

ASARCO INCORPORATED
P. O. BOX 5747
TUCSON, AZ 85703-0747

Remitter: SAME - CK #03660
792-3010

Assignor:

| SERIAL NO. |
| --- |
| AMC 134462 PENNSYLVANIA #1 |

*REFER TO THE ABOVE CASE SERIAL NUMBER IN ALL CORRESPONDENCE. PLEASE INFORM THIS OFFICE OF ANY CHANGE IN ADDRESS.*

NOTE: This notice is a receipt for monies paid the United States. If these monies are for required fees in connection with your application to lease, purchase, enter, or otherwise acquire an interest in public lands or resources, this receipt is not an authorization to utilize the land applied for and it does not convey any right, title, or interest in the land for which application is made.

RECEIPT

(Lode Claim)

**RUSH**

Notice is hereby given that Western Building and Mining Co., Inc. whose mailing address is P.O. Box 4006, Reading, PA 19606 by its undersigned agent, makes this location of the PENNSYLVANIA No. 1 lode mining claim, in WEAVER Mining District, County of YAVAPAI, State of Arizona.

The claim is 1465 feet± in length along the vein or deposit of mineral bearing rock in place and 600 feet or less in width ( 300 feet or less on either side of the center line of the claim), forming a claim in the shape of a parallelogram. The general course of said claim is NE

This Notice is posted on the centerline of the claim which location monument is in Section 14, Township 10N, Range 5W, GSRM

The location monument of said claim is located approx. N06°W, 1297'± from the SW corner of Section 14, Township 10N, Range 5W, GSRM, Arizona and said claim lies within the SW 1/4 SEC. 14 & SE 1/4 SEC. 15, T.10N, R.5W. GSRM.

The surface boundaries of the claim are described as follows: Beginning at the discovery monument and running thence N66°E 895'± to the center of the east end line and the true point of beginning thence (clockwise) S43°E 310'± to corner 1 thence S66°W 1495'± to corner 2 thence N43°W, 310'± to center west end line, thence N43°W, 310'± to corner 3, thence N66°E 1465'± to corner 4, thence S43°E, 310'± to the point of beginning.

There are seven substantial posts, projecting at least 4 feet above the surface of the ground, or stone monuments, at least 3 feet high, one for the location monument, one at each of the four corners and one at the center of each end line as prescribed by A.R.S. §27-204.

Located, dated and posted on the ground this 22ND day of AUGUST, 1990.

The original Notice of Location of this claim is recorded in the official records of YAVAPAI County, Arizona, as follows:

| DATE RECORDED | BOOK | PAGE | BLM SERIAL NO. |
|---|---|---|---|
| JUNE 30, 1981 | 1392 | 661 | AMC 134462 |
| AMENDED NOTICE AS FOLLOWS: | | | |
| JULY 17, 1990 | 2270 | 319 | |

This amendment is made for purposes of more accurately describing the boundaries hereof and correcting errors or omissions (if any) contained in the original location notice. This amendment is made without waiver of the rights previously acquired under the location hereof. If for any reason it is determined that this notice is ineffective as an amendment of the location of this claim, the undersigned intends that this amendment shall serve as an original location of the area described herein as of the date of posting hereof.

Western Building and Mining Co., Inc.

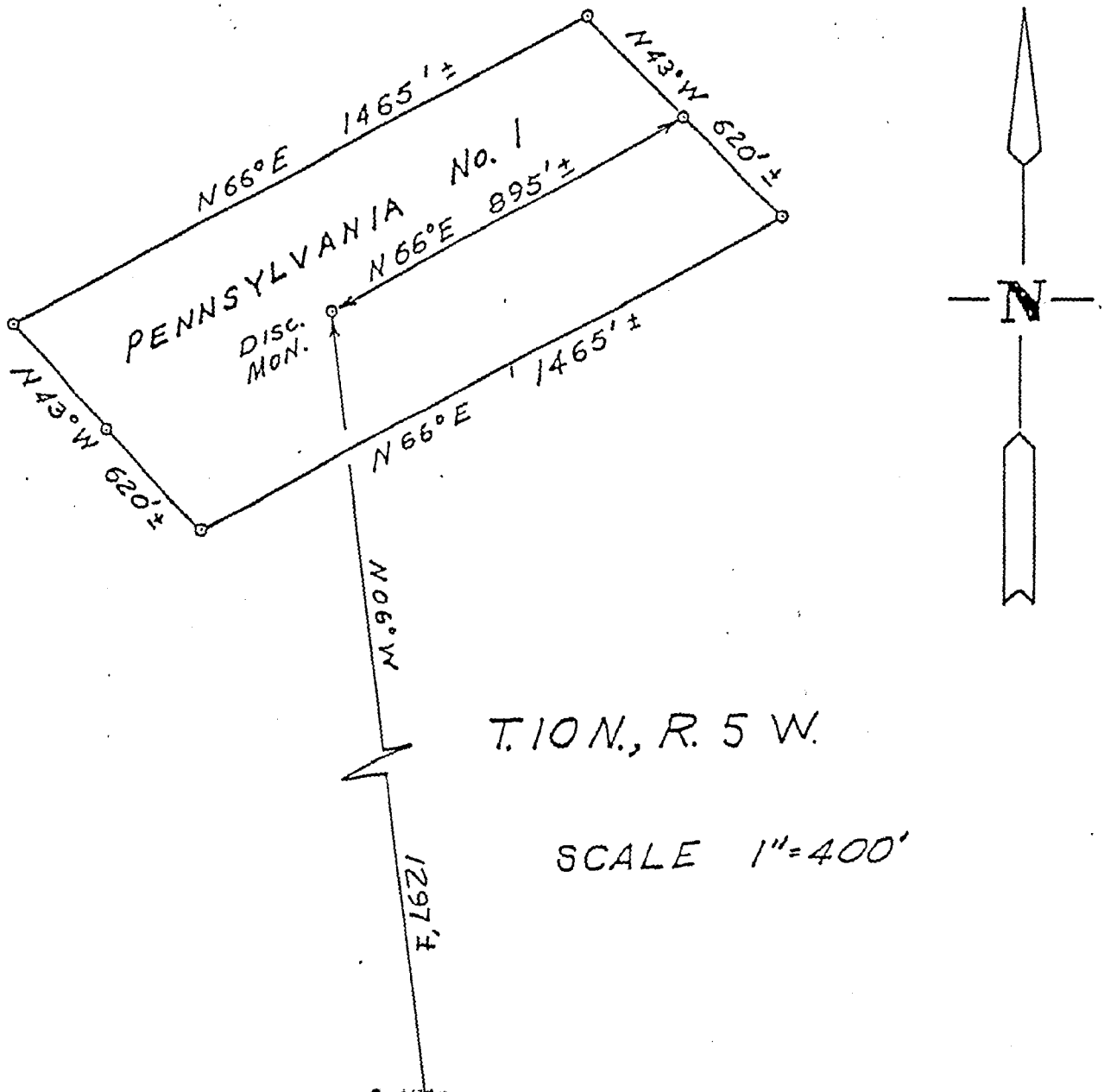
BOOK 2281 PAGE 357

RECORDER YAVAPAI COUNTY ARIZONA

INSTRUMENT # 9032306
OFFICIAL RECORDS OF
YAVAPAI COUNTY
PATSY C. JENNEY
REQUEST OF:
ASARCO
DATE: 08/23/90 TIME: 10:00
FEE: 5.00 SC: 4.00 PT:
BOOK 2281 PAGE 357 PAGES: 002

BY William D. Gay
ASARCO Incorporated
William D. Gay, Agent

# PENNSYLVANIA No. 1 (AMENDED)




T.10N., R.5W.

SCALE 1"=400'

BOOK 2281 PAGE 3
15 14
22 23

STATE OF ARIZONA } ss

County of Yavapai

I PATSY C. JENNEY-COLON, County recorder, in and for the County of Yavapai, State of Arizona, and custodian of the records of such office, do hereby certify that the foregoing is a full, true and correct copy of the record as same appears in my office.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal in the City of Prescott, County of Yavapai, State of Arizona.

on this, the 23 day of Aug.

A.D., 19 90

Glen Deerwedge

Deputy Recorder

# United States Department of the Interior

BUREAU OF LAND MANAGEMENT
ARIZONA STATE OFFICE
3707 N. 7TH STREET
P.O. BOX 16563
PHOENIX, ARIZONA 85011

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
9605 (942)
M.S. No. 4876

ASARCO Incorporated
AUG 2 1990
SW Exploration

July 31, 1990

Mr. Gordon W. McLain
U. S. Mineral Surveyor
1520 West San Lucas Drive
Tucson, Arizona 85704

Dear Mr. McLain:

Enclosed is the Official Order for Mineral Survey of one lode which has been issued in accordance with Application for Survey of Mining Claim received from Western Building and Mining Co., Inc. This survey has been designated as Mineral Survey No. 4876.

Also enclosed are the following items:

1. Uncertified copy of the Location Notice
2. Mining District Sheet
3. Master Title Plats

We have enclosed blank forms for the original and duplicate title page (3860-10) and for the final field notes (9600-20, carbon sets). The certificate page will be final typed in this office and returned with the draft field notes for your signature.

Please return the location notice copies with your completed survey returns.

If any questions arise concerning this survey, please do not hesitate to call our office at 640-5544.

Sincerely,

James P. Kelley

James P. Kelley
Chief, Branch of Cadastral Survey

Enclosures

cc: ASARCO Incorporated
w/o enclosures

FILE

New York, September 7, 1990

ASARCO Inco.

SEP 12 1990

SW Exploration

CONFIDENTIAL

MEMORANDUM FOR Exploration Supervisors

Yesterday we terminated the Yarnell Agreement for a number of good reasons, some of which may be summarized as follows:

- The estimated ROI indicated even during the early going before we know that water acquisition, permitting and reclamation cost would be way high was marginal, and creative financing such as low interest gold loans would have been required to make the project even marginally attractive. After these costs became evident the estimated ROI was nil.

- It would be advantageous to Asarco to own ounces of gold in the ground and to be seen as a significant producer of gold, and we might take on a ROI marginal project as a result. However, Yarnell would have produced 37,000 ounces of gold a year, and for only 4 years and, therefore, would not have added significantly either to our ore reserves or to gold production totals, or to the public perception of Asarco as a gold producer.

- Yarnell ore reserves were determined at a 3-1 waste ore ratio. A higher mineral inventory could have been drilled, but waste ore ratio were such that we could have added to ore reserves only at gold prices far higher than any now forecast by anyone. The obvious result of this is that the financial upside of a project there is limited or at best highly suspect. The downside is ripe with adverse possibilities. Indications were that permitting would have been expensive, but there is no way of predicting with precision how expensive. A one million dollar swing in permitting or any cost can wreck a ROI on a Yarnell-sized project.

- Uncertainty in required reclamation costs aggravated by the proximity of the project to both the village of Yarnell and Highway 78 was a severe problem. It is obvious that the prospect of not marking much money combined with the possibility of difficult media attention (impacting on Ray, Mission and Hayden) was a serious and obvious deterrent.

The mining gossip press already has speculated that we will drop out of Yarnell because it is too small. That speculation is dead wrong and I am concerned some of our people might be listening to the wrong signal. We dropped out of Yarnell not because it is too small, but because we did not think we could make enough money there to cover obvious risks.

Our objectives and criteria have not changed. We will explore small deposits, and when the geometry, tonnages and grade of such deposits conspire together to indicate good profits we will mine them, bearing in mind that the smaller the deposit, the better the required ROI. Please note the above as a reiteration of many previous statements of mine on this subject.

Our current practice is to butt our heads doggedly against obvious permitting problems which might get worse if permitting a mining operation is attempted. We may reconsider this policy, but again only on a case-by-case basis. In the meanwhile, please do not read anything into our Yarnell experience that is not there.

R. L. Brown

R. L. Brown

RLB:mc

cc: W L Kurtz
JW Sell

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
ARIZONA STATE OFFICE
3707 N. 7TH STREET
P.O. BOX 16563
PHOENIX, ARIZONA 85011

TAKE PRIDE IN AMERICA

S.W. MINING DEPT.
SEP 17 1990
TUCSON

IN REPLY REFER TO:
9605(942)
M.S. No. 4876

September 13, 1990

Mr. Gordon W. McLain
U.S. Mineral Surveyor
1520 West San Lucas Drive
Tucson, Arizona 85704

Dear Mr. McLain:

Enclosed is an Amended Order for M.S. No. 4876. ASARCO discovered that the Amended Notice of Location for the Pennsylvania No. 1 lode dated July 17, 1990, showed Range 5 East instead of 5 West. They have submitted a corrected Amended Location Notice dated August 22, 1990, for this lode.

The uncertified copy of the corrected location notice is included with copies of the Mining District Sheet and Master Title Plat for this survey. Please include these items with the Official Order for Mineral Survey No. 4876 issued to you on July 31, 1990.

If you have any questions, please call Dean Mac Donald at (602) 640-5544.

Sincerely,

James P. Kelley

James P. Kelley
Chief, Branch of Cadastral Survey

Enclosures

cc: ASARCO Incorporated
w/o enclosures

cc: J.D. Sell
W.D. Gay
9/17/90

ASARCO
SEP 17 1990
SW Exploration

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

JDS

September 14, 1990

ASARCO, Inc.
Attention: Mark Miller
Jim Sell
P. O. Box 5747
Tucson, Arizona 85703

Gentlemen:

Enclosed are the results of our evaluation of sample preparation procedures following Rick Schwarz' approach on four samples of drill cutting rejects from your Yarnell project submitted by Mark Miller.

Following the sample preparation procedure, which is outlined below, each resulting pulp was fire assayed for gold by standard procedures using a 1 assay-ton portion of the sample. The prep procedure involved successive stages of size reduction through:

1. a Morse Bros. jaw crusher to produce a nominal minus 1/2 inch product

2. a TM jaw crusher to produce a nominal minus 10 mesh product

3. a Braun disc pulverizer to produce a nominal minus 60 mesh product (which is difficult to do)

4. a Labtechnics "Big Bowl" ring mill with a "flying saucer"-shaped pulverizing element utilized to produce a homogeneous assay pulp.

The product of each device was subjected to screen analysis, the results of which are enclosed.

I have calculated the variance of the relative differences between the various assays from each comminution stage and have reported these results adjacent to the assay results for gold. You may wish to re-evaluate the raw data and perform your own statistical study.

My review of the results brought the following thoughts to mind:

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

1. The use of the Morse Bros. crusher probably was not necessary on this material; the TM crusher was quite capable of handling the initial size reduction.

2. The two higher grade samples had acceptable variances (<11.5% squared) at the split of the original reject material, whereas the two lower grade samples initially were unacceptable by Rick Schwarz' criterion. The first stage of crushing improved the variance of sample YM 90 145-150, but the variance of YM 88 245-250 did not improve until it had passed through the disc pulverizer.

3. A product sized somewhere between the fine jaw crusher product (<10 mesh) and the present disc pulverizer product (<100 mesh) probably would provide acceptable splits on all samples, high grade and low grade. The challenge is: how to prepare a product in the range of a nominal 60 mesh. Disc pulverizers score plates and bind up when operated at that setting. Perhaps a continuous ring mill (as built by Labtechnics in New Zealand) would do the job.

4. Although the Braun disc pulverizer produced a fine product, this pulverizer does not produce as homogeneous a product as the ring mill, and it is recommended that all assay pulps be prepared with a ring mill.

5. The low weight percent of material reported in the -80+100 mesh product of the screen analyses was an artifact of the screen size used -- 80 mesh instead of a preferable 60 mesh screen, which was unavailable.

6. The higher grade samples had acceptable variances to begin with, whereas the two lower grade samples were unacceptable (by Schwarz' criterion of 11.5% squared as a limit). Inasmuch as the reliability of assays near the cutoff grade probably impact decision making more than the reliability of high-grade assays, all samples should be prepared to provide acceptable variances for the low grade samples, or alternatively, rejects of the lower grade samples should be checked to determine if the reliability of their assays could be improved.

Please give us a call if we can provide any additional details.

Sincerely,
SKYLINE LABS, INC.

Edwin V. Post

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# REPORT OF ANALYSIS

JOB NO. TAJ 668
September 14, 1990
PROJECT NO.: YARNELL


ASARCO INCORPORATED
Attn: Mr. Mark A. Miller
Southwestern Exploration
P.O. Box 5747
Tucson, AZ 85703

Analysis of 28 Sample Splits

| ITEM | SAMPLE NUMBER | FIRE ASSAY Au (oz/t) ORIG | Au (oz/t) DUP | Variance* (%) |
|---|---|---|---|---|
| 2 | YM-90 145-150 A | .064 | .055 | 23.02 |
| 3 | YM-90 145-150 B1 | .062 | | 7.74 |
| 4 | YM-90 145-150 B2 | .051 | | 2.11 |
| 5 | YM-90 145-150 B3 | .052 | | .72 |
| 6 | YM-90 145-150 B4A | .048 | .042 | |
| 7 | YM-90 145-150 B4B | .055 | | |
| 9 | YM-90 195-200 A | .138 | | 5.54 |
| 10 | YM-90 195-200 B1 | .140 | | 5.51 |
| 11 | YM-90 195-200 B2 | .143 | | 5.74 |
| 12 | YM-90 195-200 B3 | .141 | .146 | 12.55 |
| 13 | YM-90 195-200 B4A | .157 | | |
| 14 | YM-90 195-200 B4B | .142 | | |
| 16 | YM-90 200-205 A | .175 | | 6.83 |
| 17 | YM-90 200-205 B1 | .160 | | 7.15 |
| 18 | YM-90 200-205 B2 | .140 | .147 | .65 |
| 19 | YM-90 200-205 B3 | .158 | | .21 |
| 20 | YM-90 200-205 B4A | .153 | | |
| 21 | YM-90 200-205 B4B | .155 | | |

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

JOB NO. TAJ 668
September 14, 1990


| ITEM | SAMPLE NUMBER | FIRE ASSAY Au (oz/t) ORIG | Au (oz/t) DUP | Variance* (%) |
|---|---|---|---|---|
| 23 | YM-88 245-250 A | .067 | | 68.63 |
| 24 | YM-88 245-250 B1 | .061 | | 85.04 |
| 25 | YM-88 245-250 B2 | .103 | | 20.84 |
| 26 | YM-88 245-250 B3 | .081 | | 1.04 |
| 27 | YM-88 245-250 B4A | .070 | .078 | |
| 28 | YM-88 245-250 B4B | .068 | | |

*NOTE: Variance reported in percent squared.

# DRILL CUTTING REJECTS

WEIGH

SCREEN ANALYSIS OF 500g.

SPLIT IN HALF

## A

CRUSH (IF NECESSARY)

SPLIT → Rejects

CRUSH

SPLIT → R

GRIND (If Necessary)

SPLIT (If Necessary) → R

PULVERIZE (LABTECHNICS)

ASSAY

A

1

## B

WEIGH

CRUSH (MORSE BROS)

B1 SCREEN ANALYSIS OF 500g.

RECOMBINE & SPLIT

WEIGH

CRUSH (TM)

B2 SCREEN ANALYSIS OF 500g.

RECOMBINE & SPLIT

WEIGH

GRIND (BRAUN DISC PULV.)

B3 SCREEN ANALYSIS OF 500g.

RECOMBINE & SPLIT

WEIGH

PULVERIZE (LABTECHNICS)

B4 SCREEN ANALYSIS

ASSAY B4A

5

ASSAY B4B

6

## B1

CRUSH

SPLIT → R

GRIND (If Necessary)

Split (If Necessary) → R

PULVERIZE (LABTECHNICS)

ASSAY

B1

2

## B2

GRIND (If Necessary)

SPLIT (If Necessary) → R

PULVERIZE (LABTECHNICS)

ASSAY

B2

3

## B3

PULVERIZE (LABTECHNICS)

ASSAY

B3

4

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-1-90

SAMPLE NO.: YM90 145-150

PRODUCT OF: ORIGINAL

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | 16 | 3.0 | 3.0 |
| -1/4+5 | 25 | 4.7 | 7.7 |
| -5+10 | 62 | 11.6 | 19.3 |
| -10+20 | 83 | 15.5 | 34.8 |
| -20+40 | 68 | 12.7 | 47.5 |
| -40+80 | 71 | 13.3 | 60.8 |
| -80+100 | 19.9 | 3.7 | 64.5 |
| -100+200 | 61.6 | 11.5 | 76.0 |
| -200 | 129 | 24 | 100. |
| TOTAL | 535.5 | 100.1 | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-1-90

SAMPLE NO.: YM90 145-150

PRODUCT OF: Morse Bros. Jaw

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | 17 | 3.0 | 3.0 |
| -1/4+5 | 31.8 | 5.7 | 8.7 |
| -5+10 | 67.6 | 12.1 | 20.8 |
| -10+20 | 85.1 | 15.2 | 36.0 |
| -20+40 | 71.1 | 12.7 | 48.7 |
| -40+80 | 74. | 13.2 | 61.9 |
| -80+100 | 21. | 3.8 | 65.7 |
| -100+200 | 64. | 11.4 | 77.1 |
| -200 | 128.1 | 22.9 | 100. |
| TOTAL | 559.7 | 100. | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-1-90

SAMPLE NO.: YM90 145-150

PRODUCT OF: TM JAW CRUSHER

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | 2.2 | 0.4 | 0.4 |
| -5+10 | 49 | 8.7 | 9.1 |
| -10+20 | 105.1 | 18.7 | 27.8 |
| -20+40 | 85.1 | 15.1 | 42.9 |
| -40+80 | 83.1 | 14.8 | 57.7 |
| -80+100 | 21.1 | 3.7 | 61.4 |
| -100+200 | 66.1 | 11.7 | 73.1 |
| -200 | 151 | 26.8 | 99.9 |
| TOTAL | 562.7 | 99.9 | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-1-90

SAMPLE NO.: YM90 145-150

PRODUCT OF: BRAUN DISC

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | | | |
| -5+10 | | | |
| -10+20 | | | |
| -20+40 | | | |
| -40+80 | 2 | 0.4 | 0.4 |
| -80+100 | 5.6 | 1.1 | 1.5 |
| -100+200 | 292.1 | 55.5 | 57.0 |
| -200 | 226.6 | 43.0 | 100. |
| TOTAL | 526.3 | 100 | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11[illegible]

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-1-90

SAMPLE NO.: YM90 145-150

PRODUCT OF: LABTECHNICS

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | | | |
| -5+10 | | | |
| -10+20 | | | |
| -20+40 | | | |
| -40+80 | | | |
| -80+100 | | | |
| -100+200 | 1 | 0.2 | 0.2 |
| -200 | 400 | 99.8 | 100 |
| TOTAL | 401 | 100 | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAT 668

DATE: 9-5-90

SAMPLE NO.: YM90 195-200

PRODUCT OF: ORIGINAL

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | 21 | 3.4 | 3.4 |
| -1/2+1/4 | 51.3 | 8.4 | 11.8 |
| -1/4+5 | 69.6 | 11.3 | 23.1 |
| -5+10 | 107.8 | 17.6 | 40.7 |
| -10+20 | 105.7 | 17.2 | 57.9 |
| -20+40 | 81.3 | 13.2 | 71.1 |
| -40+80 | 73. | 11.9 | 83.0 |
| -80+100 | 20.9 | 3.4 | 86.4 |
| -100+200 | 42.4 | 6.9 | 93.3 |
| -200 | 40.9 | 6.7 | 100. |
| TOTAL | 613.9 | 100. | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ668

DATE: 9-5-90

SAMPLE NO.: YM90 195-200

PRODUCT OF: Morse Bros. Jaw

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | 6.3 | 1.1 | 1.1 |
| -1/2+1/4 | 46.7 | 7.9 | 9.0 |
| -1/4+5 | 69.7 | 11.8 | 20.8 |
| -5+10 | 101.2 | 17.1 | 37.9 |
| -10+20 | 106.8 | 18.1 | 56.0 |
| -20+40 | 83.6 | 14.1 | 70.1 |
| -40+80 | 75. | 12.7 | 82.8 |
| -80+100 | 21.8 | 3.7 | 86.5 |
| -100+200 | 42.7 | 7.2 | 93.7 |
| -200 | 37.4 | 6.3 | 100. |
| TOTAL | 591.2 | 100. | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-5-90

SAMPLE NO.: YM90 195-200

PRODUCT OF: TM JAW CRUSHER

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | 2.5 | 0.5 | 0.5 |
| -5+10 | 43.8 | 8.5 | 9.0 |
| -10+20 | 90.1 | 17.4 | 26.4 |
| -20+40 | 95.8 | 18.5 | 44.9 |
| -40+80 | 100.7 | 19.4 | 64.3 |
| -80+100 | 33.5 | 6.5 | 70.8 |
| -100+200 | 77. | 14.9 | 85.7 |
| -200 | 74.6 | 14.4 | 100.1 |
| TOTAL | 518.0 | 100.1 | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-5-90

SAMPLE NO.: YM90-195-200

PRODUCT OF: BRAUN DISC

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | | | |
| -5+10 | | | |
| -10+20 | | | |
| -20+40 | | | |
| -40+80 | | | |
| -80+100 | | | |
| -100+200 | 4.3 | 1.2 | 1.2 |
| -200 | 353. | 98.8 | 100. |
| TOTAL | 357.3 | 100. | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 6668

DATE: 9-5-90

SAMPLE NO.: YM90 195-200

PRODUCT OF: LABTECNICS

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | | | |
| -5+10 | | | |
| -10+20 | | | |
| -20+40 | | | |
| -40+80 | | | |
| -80+100 | | | |
| -100+200 | 0.3 | 0.1 | 0.1 |
| -200 | 348. | 99.9 | 100. |
| TOTAL | 348.3 | 100. | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 6068

DATE: 9-5-90

SAMPLE NO.: YM90 200-205

PRODUCT OF: ORIGINAL

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | 16 | 3.4 | 3.4 |
| -1/4+5 | 26.7 | 5.6 | 9.0 |
| -5+10 | 56.5 | 11.9 | 20.9 |
| -10+20 | 72.9 | 15.4 | 36.3 |
| -20+40 | 73.4 | 15.5 | 51.8 |
| -40+80 | 73.7 | 15.6 | 67.4 |
| -80+100 | 18.8 | 4.0 | 71.4 |
| -100+200 | 48.7 | 10.3 | 81.7 |
| -200 | 86. | 18.2 | 99.9 |
| TOTAL | 472.7 | 99.9 | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-6-90

SAMPLE NO.: YM90 200-205

PRODUCT OF: MORSE BROS JAW

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | 27.5 | 5.8 | 5.8 |
| -1/4+5 | 28.6 | 6.0 | 11.8 |
| -5+10 | 58.5 | 12.3 | 24.1 |
| -10+20 | 73. | 15.3 | 39.4 |
| -20+40 | 70.9 | 14.9 | 54.3 |
| -40+80 | 71.5 | 15.0 | 69.3 |
| -80+100 | 18.2 | 3.8 | 73.1 |
| -100+200 | 46.6 | 9.8 | 82.9 |
| -200 | 82.2 | 17.2 | 100.1 |
| TOTAL | 477. | 100.1 | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-6-90

SAMPLE NO.: YM90 200-205

PRODUCT OF: TM JAW CRUSHER

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | | | |
| -5+10 | 33.2 | 5.9 | 5.9 |
| -10+20 | 92.6 | 16.3 | 22.2 |
| -20+40 | 102.3 | 18.0 | 40.2 |
| -40+80 | 103.3 | 18.2 | 58.4 |
| -80+100 | 26.8 | 4.7 | 63.1 |
| -100+200 | 65.8 | 11.6 | 74.7 |
| -200 | 143.3 | 25.3 | 100. |
| TOTAL | 567.3 | 100. | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-6-90

SAMPLE NO.: YM90 200-205

PRODUCT OF: BRAUN DISC

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | | | |
| -5+10 | | | |
| -10+20 | | | |
| -20+40 | | | |
| -40+80 | | | |
| -80+100 | 3.3 | 1.2 | 1.2 |
| -100+200 | 12.7 | 4.5 | 5.7 |
| -200 | 267 | 94.3 | 100. |
| TOTAL | 283 | 100. | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 6668

DATE: 9-6-90

SAMPLE NO.: YM90 200-205

PRODUCT OF: LABTECHNICS

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | | | |
| -5+10 | | | |
| -10+20 | | | |
| -20+40 | | | |
| -40+80 | | | |
| -80+100 | | | |
| -100+200 | 0.9 | 0.3 | 0.3 |
| -200 | 280 | 99.7 | 100. |
| TOTAL | 280.9 | 100. | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-7-90

SAMPLE NO.: YM 88 245-250

PRODUCT OF: ORIGINAL

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | 3 | 0.5 | 0.5 |
| -1/2+1/4 | 46.7 | 8.4 | 8.9 |
| -1/4+5 | 54.5 | 9.8 | 18.7 |
| -5+10 | 92.3 | 16.7 | 35.4 |
| -10+20 | 94.4 | 17.1 | 52.5 |
| -20+40 | 69.8 | 12.6 | 65.1 |
| -40+80 | 59.1 | 10.7 | 75.8 |
| -80+100 | 15.5 | 2.8 | 78.6 |
| -100+200 | 42.2 | 7.6 | 86.2 |
| -200 | 75.9 | 13.7 | 99.9 |
| TOTAL | 553.4 | 99.9 | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-7-90

SAMPLE NO.: YM88 245-250

PRODUCT OF: Morse Bros Jaw

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | 8 | 1.7 | 1.7 |
| -1/2+1/4 | 30.8 | 6.6 | 8.3 |
| -1/4+5 | 36 | 7.7 | 16.0 |
| -5+10 | 72.6 | 15.5 | 31.5 |
| -10+20 | 80.2 | 17.2 | 48.7 |
| -20+40 | 63.6 | 13.6 | 62.3 |
| -40+80 | 54.5 | 11.7 | 74.0 |
| -80+100 | 14.6 | 3.1 | 77.1 |
| -100+200 | 39.1 | 8.4 | 85.5 |
| -200 | 67.4 | 14.4 | 99.9 |
| TOTAL | 466.8 | 99.9 | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-7-90

SAMPLE NO.: YM 88 245-250

PRODUCT OF: TM JAW CRUSHER

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | 5.5 | 1.0 | 1.0 |
| -5+10 | 69 | 12.5 | 13.5 |
| -10+20 | 114.9 | 20.8 | 34.3 |
| -20+40 | 90.7 | 16.4 | 50.7 |
| -40+80 | 79.4 | 14.4 | 65.1 |
| -80+100 | 24.3 | 4.4 | 69.5 |
| -100+200 | 66.1 | 12.0 | 81.5 |
| -200 | 101.6 | 18.4 | 99.9 |
| TOTAL | 551.5 | 99.9 | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-7-90

SAMPLE NO.: YM88 245-250

PRODUCT OF: BRAUN DISC

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | | | |
| -5+10 | | | |
| -10+20 | | | |
| -20+40 | | | |
| -40+80 | | | |
| -80+100 | | | |
| -100+200 | 43.5 | 8.5 | 8.5 |
| -200 | 467. | 91.5 | 100. |
| TOTAL | 510.5 | 100. | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

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

# SCREEN ANALYSIS

JOB NUMBER: TAJ 668

DATE: 9-7-90

SAMPLE NO.: YM 88 245-250

PRODUCT OF: LABTECHNICS

| | GRAMS | (%) | Cumulative(%) |
|---|---|---|---|
| +1/2 | | | |
| -1/2+1/4 | | | |
| -1/4+5 | | | |
| -5+10 | | | |
| -10+20 | | | |
| -20+40 | | | |
| -40+80 | | | |
| -80+100 | | | |
| -100+200 | 1.5 | 0.4 | 0.4 |
| -200 | 343 | 99.6 | 100. |
| TOTAL | 3445 | 100. | |

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

To JDS

Date 9/14 Time 4:39 ☐ AM ☐ PM

**WHILE YOU WERE OUT**

M Ken Brook

of

Phone (702) 825-0719
Area Code Number Extension

| | | | |
|---|---|---|---|
| TELEPHONED | ✓ | PLEASE CALL | ✓ |
| CALLED TO SEE YOU | | WILL CALL AGAIN | |
| WANTS TO SEE YOU | | URGENT | |
| RETURNED YOUR CALL | | | |

Message Re Yarnell

Nevada funded client

M.
Operator

AMPAD EFFICIENCY®

REORDER #23-000

Cambriare so.
Energy Fuels

Penny Pat.
continue?

? On AIME paper Phoenix.
1992

? Rejects, pulps, coal?

Water

People (noise)

Reclamation

SW Sat.

Steve Poltes 9-24
will get back on
these items

He has key to house
call American for key before going up

JDS

**ASARCO**

**Southwestern Exploration Division**

September 17, 1990

W.D. Gay

Pennsylvania Patent
Yarnell Project
Yavapai County, AZ

Prior to OKing any additional expenses on the Pennsylvania claim, check with me as to who is to pay for this work.

James D. Sell

JDS:mek

cc: W.L. Kurtz

JDS

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

September 25, 1990

Mr. Steven C. Potter, President
NORGOLD RESOURCES, INC.
Suite 206-475 Howe Street
Vancouver, B.C. V6C 2B3
Canada

People - Things
Yarnell Project
Yavapai Co., Arizona

Dear Steve:

As per our telephone conversation of September 24, 1990:

1. Asarco will complete the surveying portion for patent process for the Pennsylvania No. 1 unpatented mining claims (AMC 134462). The U.S. Mineral Surveyor:

   Mr. Gordon W. McLain
   McLain - Harbers Co., Inc.
   Aerial Mapping and Surveying
   720 West Prince Road
   Tucson, Arizona 85705

   Phone: 602/887-7272

   Mineral Survey No. 4876.

   It is my understanding that the work is nearly completed with the setting of the corners, and only the final write-up is needed. The survey will be sent to you when received, for follow-up in the process.

2. Asarco will soon be vacating the house at Yarnell and a note sent to the owner:

   Mr. John Yannuzzi
   c/o YOU (Yannuzzi Overland Unlimited)
   527 Church
   Hazelton, Pennsylvania 18201

   Phone: 717/454-4762
   800/248-4762

Mr. Yannuzzi also has a house in Yarnell which he occupies at various times. The phone number is 602/427-3556.

The Yarnell Hill house phone is 602/427-3848.

3. At the Yarnell Hill house and yard, are all the "A" splits (sent to assayer and rejects returned), and "B" splits, the second split at the drill site. Also stored are the pulps from all the assays, and the logging drill cuttings chip trays. The sawn core half is stored in Tucson.

4. As you are aware, Asarco found Mr. Steve Keehner an excellent man to do all kinds of things from sampling to back-hoe work, reject handling and observer for the property and house.

It is my understanding you have the key to the house at Yarnell and may be contacted at the Americinn Motel, Wickenburg, Arizona, phone 602/684-5461.

James D. Sell

JDS:mek

cc: W.L. Kurtz
W.D. Gay
M.A. Miller

# ASARCO

**Exploration Department**
Southwestern United States Division

September 25, 1990

Mr. J. Yannuzzi
527 Church
Hazelton, PA 18201

Dear Jack:

As you now know, Asarco has terminated its agreement with Norgold Resources. All billing as of 9/20/90 (telephone, electric) should be sent to Norgold for payment.

Thanks for all your help, cooperation and involvement in this very interesting project. Please give my regards to Herk.

Respectfully,

Mark A. Miller
Geologist

MAM:mek

cc: J.D. Sell
C.L. Snow

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

Heritage 5000
Dec 31 1989

Western Alcy
4 - 1000 Sept Dec 1989

Jeff Erdman, Auditor
Suite 300 1195 W Broadway
Vancouver BC V6H 3X6
FAX 604 737-0048

Copy to Norgold
ph. 604 733-1221

FAX 604-737-0048

JDS

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

VIA FAX

September 27, 1990

Mr. Jeff Erdman, Auditor
Suite 300, 1195 W. Broadway
Vancouver, B.C. V6H 3X6
Canada

Yarnell Project

Dear Mr. Erdman:

Attached are copies of the items you requested:

1. Letter to F.B. Heintzelman with payment of $5000, December 1989.

2. Letters to Western Building & Mining Co., Inc. with payments of $1,000 for September, October, November and December 1989.

Sincerely yours,

James D. Sell

JDS:mek
Atts.

cc: Norgold Resources Inc. (Vancouver)
W.L. Kurtz

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

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

December 20, 1989

Mr. Forrest B. Heintzelman
1315 Cedar Crest Boulevard
Allentown, Pennsylvania 18104

Yarnell Project
Yavapai Co., AZ

Dear Mr. Heintzelman:

Enclosed is Asarco's check for $5000 as payment due December 30, 1989 as stated in Article 2 (b) of your Agreement and Option to Purchase with Norgold Resources (US) Inc., dated June 30, 1989.

Sincerely,

James D. Sell

JDS:mek
enc.

cc: C. Moat - Norgold Resources (US) Inc.
R.L. Brown
W.L. Kurtz
S.L. Lakosky
M.A. Miller
C.L. Snow

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

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

CERTIFIED MAIL
RETURN RECEIPT

November 22, 1989

Mr. A.J. Roman, President
Western Building & Mining Co., Inc.
P.O. Box 4006
Reading, PA 19606

Western Building
Monthly Payment
Yarnell Project
Yavapai Co., AZ

Dear Mr. Roman:

Enclosed is Asarco's check of $1,000 U.S. for the monthly payment of December 1, 1989, due Western Building as per Article 4 of the Norgold Resources, Inc. - Western Building and Mining Co., Inc. Agreement dated December 30, 1988.

Sincerely,

James D. Sell

James D. Sell

JDS:mek

cc: W.L. Kurtz
C.L. Snow
C. Moat - Norgold

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

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

CERTIFIED MAIL
RETURN RECEIPT

October 24, 1989

Mr. A.J. Roman, President
Western Building & Mining Co., Inc.
P.O. Box 4006
Reading, PA 19606

Western Building
Monthly Payment
Yarnell Project
Yavapai Co., AZ

Dear Mr. Roman:

Enclosed is Asarco's check of $1,000 U.S. for the monthly payment of November 1, 1989, due Western Building as per Article 4 of the Norgold Resources, Inc. - Western Building and Mining Co., Inc. Agreement dated December 30, 1988.

Sincerely,

ORIGINAL SIGNED BY
J. D. SELL

JDS:mek

James D. Sell

cc: W.L. Kurtz
C.L. Snow
C. Moat - Norgold

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

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

CERTIFIED MAIL
RETURN RECEIPT

September 22, 1989

Mr. A.J. Roman, President
Western Building & Mining Co., Inc.
P.O. Box 4006
Reading, PA 19606

Western Building
Monthly Payment
Yarnell Project
Yavapai Co., AZ

Dear Mr. Roman:

Enclosed is Asarco's check of $1,000 U.S. for the monthly payment of October 1, 1989, due Western Building as per Article 4 of the Norgold Resources, Inc. - Western Building and Mining Co., Inc. Agreement dated December 30, 1988.

Sincerely,

ORIGINAL SIGNED BY
JAMES D. SELL

James D. Sell

JDS:mek

cc: W.L. Kurtz
C.L. Snow
C. Moat - Norgold

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

# ASARCO

**Exploration Department**
Southwestern United States Division

James D. Sell
Manager

CERTIFIED MAIL
RETURN RECEIPT

August 25, 1989

Mr. A.J. Roman, President
Western Building & Mining Co., Inc.
P.O. Box 4006
Reading, PA 19606

Western Building
Monthly Payment
Yarnell Project
Yavapai Co., AZ

Dear Mr. Roman:

Enclosed is Asarco's check of $1,000 U.S. for the monthly payment of September 1, 1989, due Western Building as per Article 4 of the Norgold Resources, Inc. - Western Building and Mining Co., Inc. Agreement dated December 30, 1988.

Sincerely,

James D. Sell

James D. Sell

JDS:mek

cc: W.L. Kurtz
C.L. Snow
C. Moat - Norgold

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

# ASARCO

**Exploration Department**
Southwestern United States Division

September 28, 1990

Mr. Frank Sepulveda, Deputy Mine Inspector
Arizona State Mine Inspector's Office
1616 West Adams, Suite 411
Phoenix, Arizona 85007

Yarnell Mine
Stop Notice

Dear Mr. Sepulveda:

This letter is to confirm our telephone conversation of today, in which I told you ASARCO Incorporated had terminated its agreement with NORGOLD RESOURCES (US) INCORPORATED.

Asarco requests that it no longer be held responsible for any activities at the Yarnell Mine in T10N, R5W, Yavapai County, Arizona.

If you have any questions, please call me at 602-791-3010.

Very truly yours,

William D. Gay

William D. Gay
Land Engineer, SWED

WDG:mek

cc: W.L. Kurtz
T.E. Scartaccini
J.D. Sell
M.A. Miller
Norgold Resources

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

The Northern Miner, Oct. 1, 1990 p. 23.

JDS

**ASARCO**

**Southwestern Exploration Division**

October 5, 1990

J.D. Sell

Yarnell House Status
Yarnell Project

The refrigerator problem is resolved. The old unit was replaced with another for $50.

The pump problem is still unresolved. Wickenburg Pump came and looked at the pump on October 3, 1990. There is a voltage drop between the house and the pump which causes insufficient power to run the pump. The most likely cause is the power cable between the pump and the house. The pump will also need to be run by generator in order to insure that the pump has not been damaged prior to hookup.

The pump was running fine the last time we occupied the house.

Mark A. Miller

MAM:mek

cc: W.L. Kurtz
S. Potter - Norgold

THE UNIVERSITY OF ARIZONA
Tucson

65245

# INVOICE

Date Oct 11, 90

Invoice No. 1212

12

Mr. John Malusa
ASARCO, Tucson
1150 N 7th Ave
Tucson, AZ 85703

Please make check payable to
THE UNIVERSITY OF ARIZONA and mail to Department of: Geosciences

Analysis of 1 K-Ar samples at $500 per sample

1. Yarnell # 1 UAKA- 90 054

Total $ 500

Please return one copy of invoice with your check.

SDS

FILE
JDS

# ASARCO

Exploration Department
R. L. Brown
Vice President

New York, October 12, 1990

James Sell, Manager
Tucson Office

Yarnell Project, Arizona

Dear Mr. Sell:

Please find a copy of incoming correspondence from Norgold, in which they ask us, in conformance with the agreement, for special warranty deed and assignment and for a confirmation of the assessment work has been filed. Please send him copies of our affidavits of assessment work, and please work with Mr. Haggard to draw up the special warranty deed and then forward the deed to Norgold in Vancouver.

Yours very truly,

R. L. Brown

R.L. Brown

RLB:lj

cc: J.L. Woods, Legal Dept.

cc: W.D. Gay
(10/23/90)

ASARCO Incorporated

OCT 22 1990

SW Exploration

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

HEAD OFFICE:
210-475 HOWE STREET
VANCOUVER, B.C. V6C 2B3
TEL: (604) 681-5566
FAX: (604) 687-8789

F. T. G.
OCT 12 1990

VIA TELEFAX

October 3, 1990

R. L. B.
OCT 11 1990

Yarnell

Asarco Incorporated
180 Maiden Lane
New York, New York
10038

Attention: Mr. R.L. Brown, Vice-President

Dear Dick:

We have received Asarco's termination notice with respect to the Yarnell Project, dated August 28, 1990. We, too regret that drilling to date has not proven the existence of an ore deposit of sufficient size to interest.

In accordance with Article 5 of the Exploration and Option Agreement between the parties dated January 30, 1989, we would appreciate the receipt of the special warranty deed and assignment referred to in subparagraph 5.3 and confirmation of the filing of assessment work as contemplated by subparagraph 5.4.

We have appreciated the good work Asarco has done on the Yarnell project and the amount of technical information which Asarco has provided to Norgold in recent weeks. I will continue to work with Jim Sell regarding the transfer of the drill core, cuttings, technical and property information.

Yours very truly,

NORGOLD RESOURCES INC.

Michael Philpot
Chairman of the Board

MP/kg

RECEIVED
OCT 9 1990
EXPLORATION DEPT.

U.S. EXPLORATION OFFICE:
SUITE G-177 4600 KIETZKE LANE, RENO, NEVADA USA 89502 TEL: (702) 827-1755 FAX: (702) 827-1802

FOR THE RECORD

cash and total costs of $252 and $305 per ounce, respectively. Proven and probable reserves are 462,300 ounces gold from material grading 0.069 opt. Source: AR. Contact: Eliseo Gonzalez–Urien, vice–president exploration, Vancouver, BC, (604)682–7082.

**REA GOLD CORP.**
**Nevada Property Acquisition**

Vancouver, BC – Rea Gold has entered into an agreement with holders of +80% of the shares of Kookaburra Gold Corporation to acquire Kookaburra's assets. Kookaburra's main assets are the SFS copper/molybdenum property near Luning, NV; an option to acquire the Hoodoo property in Custer Co., ID; and properties in British Columbia.

Rea has paid Kookaburra $50,000 for a three week due diligence period ending October 31, 1990 (now extended to Nov. 9). The purchase price is C$1.3 MM – half in cash and half in stock.

The SFS property has a reported inferred reserve defined by previous owners on the basis of widely–spaced drilling of 100.0 MM tons grading 0.35% copper and 0.015% molybdenum. Kookaburra reports the property has anomalous gold values the nature of which is not understood.

Kookaburra holds an option to earn a 100% interest in the Hoodoo mine subject to a 60% earn–in by a third party. The mine was in production between 1973 and 1977 and, although records are incomplete, produced between 200,000 and 300,000 tons grading 7% zinc, 0.5% lead, 0.9 opt silver, and very minor gold.

Rea is actively looking for additional U.S. acquisitions. Source: NR, PC. Contact: Larry W. Reaugh, president, Vancouver, BC, (604)684–7527.

**U. S. ENERGY CORP.**
**Lincoln Gold Properties JV**

Riverton, WY – U.S. Energy and Seine River Resources have acquired the 4,000–acre Lincoln gold properties from FMC Gold Company for $5.0 MM. Of the total price, $4.5 MM was paid by USE and $500,000 was previously paid by Seine River for a purchase option.

The Lincoln properties are located in the Mother Lode District of California near Sutter Creek in Amador County. The new venture will control about 2.5 miles of the Mother Lode belt that extends through Amador County.

FMC purchased the property with the Meridian acquisition earlier this year. Meridian had driven a 3,000–foot tunnel and conducted drilling and other UG exploration work. Approximately 220,000 ounces of gold from material grading 0.351 opt are reported to have been outlined. Gold mineralization has also been identified on adjacent properties which are part of the acquisition.

USE and Seine River have agreed to form a new JV and contribute the properties acquired. Seine River will pay USE $2.0 MM in two installments during the next year to maintain a 50% interest in all cash flows derived from the operation. The JV will be operated by a five member management committee – three members from USE and two from Seine River.

USE, operator of the project, intends to move quickly to complete a feasibility study including mill construction. A toll milling agreement at a nearby operating mill is also being pursued. Source: NR. Contact: John L. Larsen, president, Riverton, WY, (307)856–9271.

**U. S. GOLD CORP.**
**Sale Of White Pine Gold Property**

Denver, CO – U.S. Gold has sold their OP HL White Pine gold property and related assets in Nevada to a privately held company for about $0.6 MM, including some debt forgiveness. Proceeds are being held in a restricted account with the Company's senior secured bank creditor. USG will record a $2.5 MM loss on the sale and report it in the third quarter financial report. Source: NR. Contact: William W. Reid, president, (303)629–1515.

**USMX INC.**
**First Production From Casino**

Lakewood, CO – USMX officially began production from the Casino mine on October 10, 1990 with the first dore' pour of approximately 850 ounces gold. The Casino, a JV between USMX and Pegasus Gold Incorporated, is located about 80 miles northwest of Ely, NV.

The HL facilities were engineered and constructed for a capital cost of $1.5 MM with production projected at 8,000 ounces gold in 1990 and 21,000 ounces in 1991. USMX estimates reserves at 624,000 tons grading 0.059 opt gold (36,800 ounces).

The Winrock property, located approximately four miles from Casino, is also part of the JV and is currently in a feasibility stage. The Company expects completion of the feasibility study in November 1990 and production in late 1991, adding operating life to the project. Previously reported reserves for the Winrock are 39,000 ounces gold from material grading 0.043 opt. Source: WestMAR Research Report, NR. Contact: Keith R. Hulley, president, Lakewood, CO (303)985–4665.

## VIEWPOINTS

**Its Off The Record And Don't Quote Me But . . .**

. . . Boise Cascade has had a significant exploration staff reduction. Jerry Lewis is now running a one–man minerals exploration show. Boise Cascade is reported to be changing emphasis to immediate cash flow from oil and gas deals. Barney Guanera is now Westchester Gold.

. . . Billiton has a "For Sale" sign out for their gold exploration properties and people – orders are to "sell the projects and yourself"; Mellon Bank is reported to be the financial representative.

. . . Molycorp is closing down all minerals exploration by December 31. Exploration offices in Australia, Canada, and Brazil have already closed, Denver is next. Current producing operations will continue but probably not for long.

. . . Chevron, Billiton (Shell), Molycorp (Union) – the last of the BIG OILS minerals programs bites the dust. Coupled with Kerr–McGee's retrenchment to Oklahoma City, that makes four in the last six months.

. . . All is not bleak though, Norgold has some 70 companies kicking the tires of their Yarnell property.

. . . Sharon Steel's minerals group is reported to be reorganizing into a new company as a result of SS's bankruptcy. SS owns Washington Mining who is running the Sunnyside mine at Silverton, CO, and has a number of other mineral properties, mostly in NM.

Y-10.5
11-31009

JDS

# ASARCO

Southwestern Mining Department
T. E. Scartaccini
General Manager

November 1, 1990

ARIZONA STATE LAND DEPARTMENT
1616 West Adams
Phoenix, AZ 85007

Gentlemen:

YARNELL PROJECT
Yavapai County, Arizona

Enclosed is an Affidavit of Performance of Annual Assessment Work and Mining Activity for Assessment Year 1990 of the Kachina Doll Arizona State Lease No. 11-31009.

Very truly yours,

G. H. Myers
Accounting Manager

GHM/mck
encl.

cc: JDSell - w/encl.
WDGay - " "
MAMiller - " "

ASARCO Incorporated P. O. Box 5747 Tucson, Az 85703-0747
1150 North 7th Avenue Phone (602) 792-3010 Fax (602) 624-3369

# AFFIDAVIT OF PERFORMANCE OF ANNUAL ASSESSMENT WORK AND MINING ACTIVITY

STATE OF ARIZONA )
County of Yavapai ) ss

Arizona State Lease No. 11-31009

Mark A. Miller, Agent for ASARCO Incorporated, being first duly sworn, deposes and says:
Name of Lessee or Agent

That he is a citizen of the United States and more than twenty-one years of age, resides at 2851 N. Cloverland Ave., Tucson Pima County, Arizona, and is lessee of, or lessee's authorized agent of record for State Mineral Lease No. 11-31009, and is personally acquainted with the 1 (number) mining claim(s) held under said lease.

## ASSESSMENT WORK

That between the 20 day of June, A.D. 1990, and the 22 day of July, A.D. 1990, at least $100.00 worth of work and improvements were done and performed upon said lease area, not including the original location work of said claim(s). Such work and improvements were made by, or at the expense of the owners of said lease, for the purpose of complying with the laws of the State of Arizona, pertaining to assessment or annual work, (at least One Hundred Dollars worth of work for each claim) and; (Give names and addresses of miners or other workman or firm who worked the claims).

Mark Miller, ASARCO Incorporated, P. O. Box 5747,
Tucson, AZ 85703

were the men or firm employed by said owner and labored upon said claims, did said work and improvements, the same being as follows, to-wit:
(Describe work done)

Geological Reconnaissance and Rock Sampling.

## MINING ACTIVITY

That records of all mineral, rock or earth material removed from said lease area during the last lease year have been filed with the Arizona State Land Department and proper royalty credited or paid thereon, or does hereby certify under the penalty of perjury, that no mineral, rock or earth material has been removed from said lease area during the lease year.

I certify that the foregoing is a true and correct statement of the work performed, of improvements made, and of mining activity, of my knowledge.

Signature

STATE OF ARIZONA )
County of Pima ) ss

Subscribed and sworn to before me this 2nd day of November, 1990.

My Commission Expires: My Commission Expires July 8, 1992

Notary Public

70-73

JDS

# ASARCO

Southwestern Mining Department
T. E. Scartaccini
General Manager

November 5, 1990

CERTIFIED MAIL - RETURN RECEIPT REQUESTED
Office of the Recorder
Yavapai County
Administration Center
255 E. Gurley Street
Prescott, AZ 86301

Affidavit of Labor, Yavapai Mining District
Yavapai County, AZ

Gentlemen:

Enclosed is Asarco's check for $14 as the recording fee for the Affidavit of Labor for the Alvin J., Kathryn A, Kathryn B, and Pennsylvania No. 1 unpatented lode claims.

Also enclosed is a return, stamped envelope.

Very truly yours,

ORIGINAL SIGNED BY
G.H. MYERS

G. H. Myers
Accounting Manager

GHM/kh

Encl.

cc: JDSell
CLSnow

ASARCO Incorporated P. O. Box 5747 Tucson, Az 85703-0747
1150 North 7th Avenue Phone (602) 792-3010 Fax (602) 624-3369

WLR- JDS

1710–609 GRANVILLE ST.
P.O. BOX 10363 STOCK EXCHANGE TOWER
VANCOUVER, B.C.
V7Y 1G5
(604) 683-7265
FAX (604) 683-5306

NO.225(1990)
NOVEMBER 21, 1990

RECEIVED
NOV 26 1990
EXPLORATION DEPARTMENT

# George Cross News Letter

"Reliable Reporting"

COPYRIGHT
ALL REPRODUCTION
RIGHT RESERVED

PUBLISHED DAILY
SUBSCRIPTION RATE
$300.00 PER YEAR

FAX (604) 683-5306
NO.225(1990)
NOVEMBER 21, 1990

cc JCB, PGV

another vein 100 east

east assaying 0.036 oz gold/ton from a grab sample

# ASARCO

**Exploration Department**
Southwestern United States Division

VIA FAX 702-827-1802

November 27, 1990

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

Dear Tench:

With regard to our phone conversation of 11-27-90, Asarco conducted geological reconnaissance rock sampling and airborne geophysics in the east half Sec. 14, T10N, R5W. The cost of this work would exceed $4,000. I hope this information is of some help.

Sincerely,

Mark A. Miller

MAM:mek

cc: J.D. Sell

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

# ASARCO

**Exploration Department**
Southwestern United States Division

VIA FAX 702-827-1802

November 27, 1990

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

Dear Tench:

As we discussed, Asarco flew airborne geophysics over the Yarnell Project. $19,000 was spent, of which $1,000 is attributable to Section 22. The results helped to further trace the Yarnell Fault Zone. Hope this is some help.

Sincerely,

Mark A. Miller

MAM:mek

cc: J.D. Sell

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