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AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

April 24, 1975

FILE MEMORANDUM

COPPER LEACHING IN-SITU
E.I. DUPONT DE NEMOURS

On Friday, April 19, I accompanied Messers. Newton, Bergman, and Beeder of DuPont to an area in North Silver Bell, some 3500' north of the El Tiro pit, which is underlain by a partially oxidized blanket of chalcocite that might qualify for an in-place leaching test.

The area, about 500' by 700', contains 6 drill holes with variable thickness and grade, but averaging around 75' at .80% Cu. The mineralization occurs in dacite porphyry beneath leached capping averaging 85' in thickness. Topographic relief is about 150'; the water table varies between 200' and 300' depth. Probably at least 80% of the copper is in readily acid-soluble form.

The DuPont engineers showed considerable interest in the deposit and will conduct a study to determine how it ranks with several others they have investigated.

The DuPont proposal (copy attached) involves drilling and blasting a group of holes followed by circulation of dilute sulphuric acid solutions. The first phase objective will be to establish circulation in a shallow deposit and then to test copper recovery over a period of 6 to 12 months (cost: $400,000 to $600,000). According to their calculations the cost of energy in leach production per pound is only 30% of that for conventional methods. Capital and operating costs are projected at around 50% less on .80% ore based on a 50% recovery of the total copper by leaching. This (50%) appears high considering recoveries obtained in most dump leach operations. However, dump grades are generally low (± .30%) with perhaps no more than 50% of the copper in readily soluble form (copper oxides and chalcocite). In contrast, at the Blue Bird Mine where over 80% of the copper is oxide, 40% to 50% recovery is obtained by heap leach in around three months.

The critical question is whether sufficient permeability can be achieved by blasting, pressure injection and/or other techniques to permit recoveries even approaching the economic level. The odds against success are generally regarded to be heavy; however, in view of the low energy requirement relative to conventional extraction and the environmental advantages, a modest investment by Asarco in a test program is warranted, in my opinion. Reportedly Kennecott is well along on a several million dollar project at Safford which involves leaching of .60% Cu as chalcopyrite at depths below 3000'.

J.H. Courtright
J.H. Courtright

JHC:vmh
cc: J.J. Collins w/enc.
N. Visnes w/o enc.
R.B. Meen w/o enc.
W.L. Kurtz w/o enc.

JHC

JHC/leave files Silver Bell

WLK 1-27-75

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

December 30, 1974

J. H. C. FEB 3 1975

TO: W. L. Kurtz

FROM: F. T. Graybeal

Age of supergene enrichment at Silver Bell

SUMMARY

The formation of the present chalcocite blankets at Silver Bell probably occurred in the Late Tertiary and Quaternary. The clast lithology in the Cocio conglomerate is shown to be undiagnostic. The shape of the top of the chalcocite blankets closely conforms to the present topography, suggesting that enrichment is related to a modern erosion cycle. Post-mineral andesite dikes controlled the distribution of copper oxides and chalcocite in the West Oxide deposit, indicating that deposition occurred within the last 28 m.y. Estimates from erosion rates available in the literature and calculated for the Caridad deposit (see Appendix A) indicate that all the chalcocite at Silver Bell could have formed within the last 4 m.y.

INTRODUCTION

During the past decade several statements have been published concerning the age of supergene enrichment at Silver Bell. Damon (1963) obtained a 27.9 m.y. date (K-Ar) for the Cocio andesite which he described as overlying a conglomerate containing fragments of "leached ore" and suggested that a considerable amount of supergene enrichment could have occurred in the interval from 65-28 m.y. Livingston and others (1968), using evidence from Silver Bell and other mining districts, stated that a majority of the Arizona porphyry copper deposits were enriched prior to and the chalcocite blankets preserved by Mid-Tertiary sedimentary and volcanic rocks. Lowell (1974) stated that the principal period of supergene enrichment at Silver Bell occurred about 30 m.y. ago; however, this is an apparent misquote of information obtained from J. H. Courtright.

As part of the Silver Bell project, various data have been accumulated which indicate that the major cycle of supergene enrichment occurred more recently than 28 m.y. ago. These data are in conflict with prevailing published opinion on the subject and are presented below.

THE EVIDENCE

Cocio conglomerate

The Cocio conglomerate is exposed on the west side of a small hill about 5 miles east of Oxide pit. The hill is about 100 ft. high and is capped by a 27.9 m.y. andesite flow. Clasts in the conglomerate are dominantly sub-angular pebbles of quartz monzonite porphyry which differ from the porphyries in Oxide pit by the relative lack of phenocrysts. Clasts of Mt. Lord ignimbrite, alaskite, dacite, or limestone, which are common near Oxide pit, are absent.

The clasts are variably altered and most of the mafic minerals have been altered to epidote. The mineralization in the clasts was uniformly disseminated pyrite as indicated by small, empty cubic voids and by the presence of considerable transported orange-red limonite. Limonites derived from leached chalcocite were not observed.

The igneous textures, propylitic alteration, and relatively weak, disseminated pyritic mineralization in clasts from the Cocio conglomerate contrast sharply with features observed near Oxide pit. The clasts are almost certainly of local origin and contain no evidence of the former presence or absence of a chalcocite blanket in the Silver Bell district prior to 28 m.y. ago. They do indicate that the mineralization was exposed at this time, although this has never been disputed.

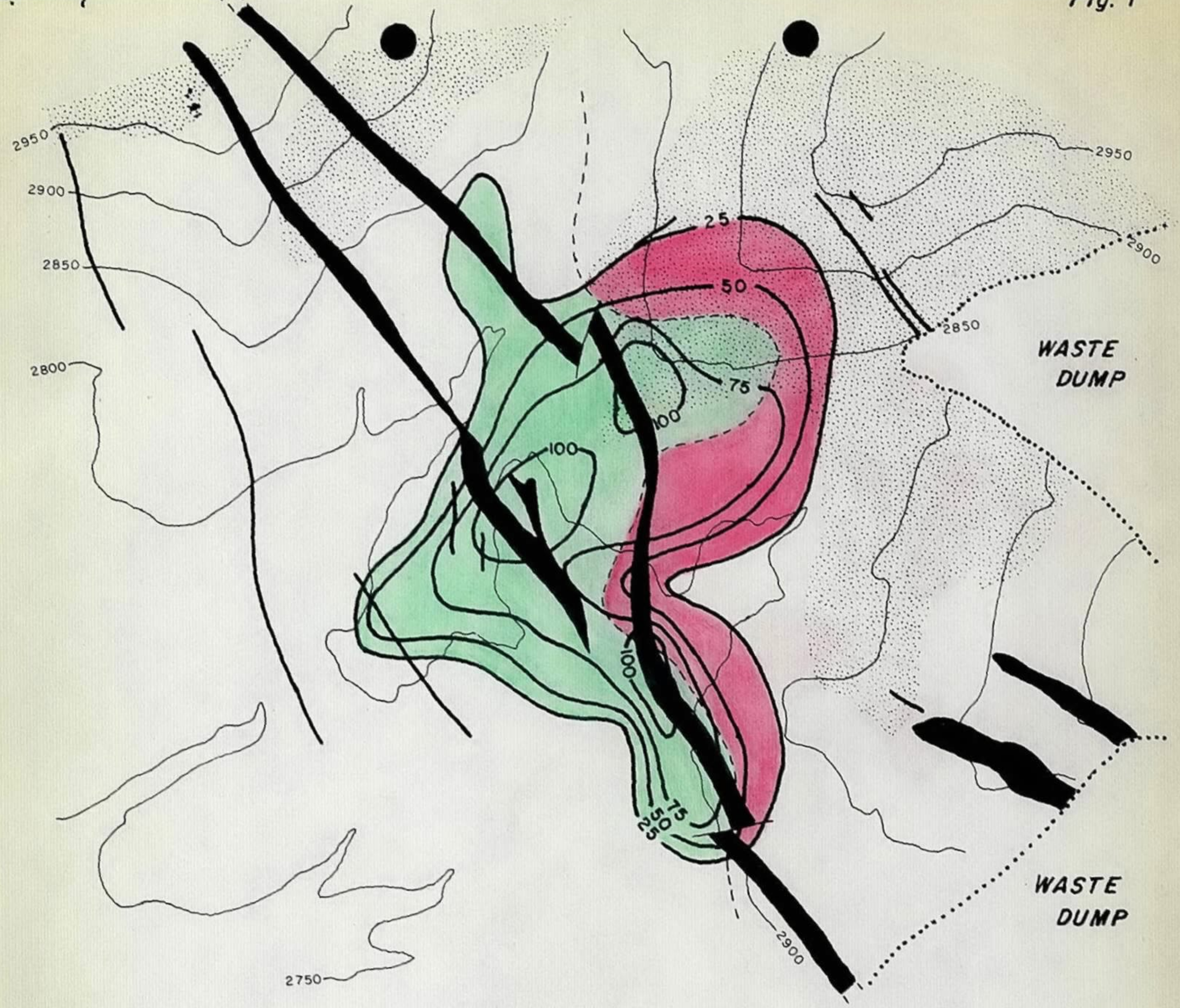
West Oxide deposit

The West Oxide deposit is a small zone of mixed copper oxides and sulfides which is located about 1500 ft. west of Oxide pit between Copper Butte and North Butte. Although not yet completely explored, it is presently estimated to contain about 1 million tons of ore in the 0.90% Cu range, of which about 80 percent is oxide copper.

Host rocks are weakly pyritized alaskite and quartz monzonite porphyry, and post-mineral (hypogene) andesite. Pervasively altered rocks with limonite after abundant pyrite occur along the northeast side of the deposit and extend into Oxide pit. The alaskite is strongly broken and appears to be a thin sheet over the deposit as most of the drill holes bottomed in quartz monzonite porphyry. The post-mineral andesite is most conspicuous in two large, northwest-striking dikes and is assumed to be equivalent to the 27.9 m.y. andesites in the Cocio area.

Of particular interest is the distribution of copper in the deposit (Fig. 1). Isopachs show that the thicknesses of the +0.40% Cu intervals reflect two controls. These intervals are thickest along a northwest-striking zone between the two andesite dikes. The intervals also show a NE-SW bulge which is parallel to and along strike of a swarm of NE-striking veins which lie farther upslope to the northeast. The presence of large amounts of oxide copper in very weakly altered and pyritized alaskite indicates that most of the copper is exotic. Figure 1 also shows that sulfide copper is dominant east of the andesite dikes and oxide copper is dominant in and west of the dikes. The sulfide copper is all chalcocite and it occurs under outcrops which indicate only minor limonite after pyrite with total sulfides averaging less than 2 volume percent.

Fig. 1



TO ACCOMPANY Report
To W.L. Kurtz
DATED Dec. 30, 1974
BY F.T. Graybeal

EXPLANATION

Andesite Dikes

Thickness of +0.40 % Cu intervals in drill holes.

Moderate strength hydrothermal alteration

> 50 % oxide Cu

> 50 % sulfide Cu

SIMPLIFIED GEOLOGIC MAP

WEST OXIDE DEPOSIT

Silver Bell District
Pima County, Arizona

SCALE 1" = 200'

F.T.G. Dec. 1974

FTG 8 MVK 2808

The above data strongly suggest that the copper in the West Oxide deposit was derived from the more strongly altered and mineralized rocks to the northeast, including mineralized skarns in the Danube mine, and was transported in solution downslope to the west along the northeast-striking veins. Upon encountering the easternmost andesite dike the copper-bearing waters spread laterally downslope to the south along the east contact of the dike. In this area the copper in the groundwater replaced the iron in what pyrite was available and the rest was precipitated as oxide copper. As water moved through the andesite dike swarm it encountered essentially fresh rocks with little or no pyrite and copper was precipitated as various oxide minerals.

The andesite dikes appear to have acted as a semi-permeable barrier to the flow of copper-bearing groundwater and, in addition, appear to have increased the pH of the water to a point where copper oxides were rapidly precipitated in and west of the dikes. I conclude, therefore, that the andesite dikes were emplaced prior to the formation of the chalcocite blanket. This chalcocite is part of a lower grade, but essentially continuous, blanket which extends into the Oxide orebody and forms the bulk of the open pit ores. By inference the present chalcocite blanket in Oxide pit is also presumed to have formed after emplacement of the andesite dikes, or, more recently than 27.9 m.y. ago. Several cross-sections of El Tiro pit also suggest that post-mineral andesite dikes have limited the extent of the chalcocite blanket in some areas indicating that the cycle of enrichment which formed the present orebody occurred more recently than 27.9 m.y. ago.

It is not possible to date the actual time interval of enrichment. An age date on the andesite dike would establish an upper age limit. However, as these dikes may be related to the Mid-Tertiary eruptive event which extended from 25-28 m.y., this date might not be particularly definitive.

It is quite clear that most of the copper in the West Oxide deposit was derived from topographically higher areas to the northeast. It is interesting that as the copper moved downslope through mineralized rock only a minor amount of copper was precipitated as chalcocite. Apparently, for thorough replacement of sulfides by chalcocite to occur, a significant interval of time relative to the speed of movement of the water is required. I believe Kenyon Richard once remarked that a stationary water table was necessary for pervasive replacement of chalcocite to occur, a belief supported by evidence in the West Oxide deposit.

Enrichment and present topography

Ransome (1919) noted that the shapes of the present topography and water table are unrelated to the top of the chalcocite blanket in the Ray and Globe-Miami districts. He believed that this was due to the development of the chalcocite blanket prior to deposition of the dacite in a terrain where the topography was different from modern topography.

The Silver Bell district is a good example of the conformable shapes of the present topography and the top of the chalcocite blanket. The upper limit of chalcocite is believed to represent the top of a former water table which has now withdrawn to deeper levels under the influence of a drier climate and/or uplift. The conformable relationship noted above suggests that the formation of the chalcocite blankets is a relatively recent event related to the development of the present topographic profile. The location of the West Oxide deposit in a topographic low into which supergene solutions would move also demonstrates that the mineralization was partly controlled by the present topography.

Enrichment factors and erosion rates

The evidence given above strongly suggests that the chalcocite blankets at Silver Bell formed within the last 28 m.y. In the absence of an absolute age date on the enrichment cycle I have attempted an estimate based on erosion rates. The following approximations were used for the calculation:

grade of capping - 0.03% Cu
grade of chalcocite blanket - 0.80% Cu
grade of protore - 0.25% Cu
thickness of capping - 100 ft.
thickness of chalcocite blanket - 200 ft.

The estimate of the grade of the chalcocite blanket is difficult because the average grade of all ore mined to date at Silver Bell only includes that above 0.60% Cu plus that in excess of 0.40% Cu which had to be moved. However, all rocks grading above the average protore grade (0.25% Cu) have undergone some chalcocite enrichment. Inclusion of this lower grade material would reduce the average grade mined to date, presently 0.84% Cu, and I have therefore used 0.80% Cu. Clearly there are thin zones of chalcocite outside the present pit which would be difficult to include in the average grade of the chalcocite blanket due to a lack of drill data. I suspect that the protore grade is also lower in these outlying areas so the enrichment factor is probably similar to that within the pits. The grade of the protore is estimated from 4 diamond drill holes (F-93, 97, 160 and D-312) which extend below the chalcocite blanket. There is clear evidence in F-160 and D-312 that primary grades are decreasing with depth, or, increasing upward. Thus, hypogene copper grades in the leached and eroded zones and in the present chalcocite blanket may have been higher. The thicknesses of the leached capping and the chalcocite blanket were derived from a study of drill logs and cross sections. These values are variable for both the capping (80-125 ft.) and the chalcocite blanket (100-250 ft.).

The amount of copper added to the deposit to form the present chalcocite blanket is

% Cu chalcocite blanket — % Cu protore = 0.80% — 0.25% =
0.55% Cu added to protore

To determine the thickness of protore which must be eroded, the protore grade must first be adjusted to allow for the 0.03% Cu which is contained in the capping and which is lost from the deposit during erosion. This is probably a high estimate for the average grade of the leached capping during the entire enrichment cycle because the grade probably increased as the grade of the underlying chalcocite blanket increased. Therefore, the actual grade of the protore which became available to the chalcocite blanket is

$$\% \text{ Cu protore} - \% \text{ Cu capping} =$$
$$0.25\% - 0.03\% = 0.22\% \text{ Cu}$$

This allows calculation of the amount of rock leached to form the chalcocite blanket as

$$\frac{(\% \text{ Cu added to chalcocite blanket})}{(\% \text{ Cu from leached protore})} \text{ thickness of chalcocite blanket} =$$

$$\frac{(0.55\% \text{ Cu})}{(0.22\% \text{ Cu})} \text{ 200 ft.} = \text{500 ft.}$$

The thickness of rock eroded from the deposit during the most recent enrichment cycle is

$$\text{total thickness leached} - \text{remaining leached capping} =$$
$$\text{500 ft.} - \text{100 ft.} = \text{400 ft.}$$

The time required to erode 400 ft. of rock can only be roughly estimated by comparison with various data in the literature. Ruxton and McDougall (1967) calculated erosion rates varying from 0.26-2.5 ft./1000 yr. on an andesitic stratovolcano in northeast Papua for areas with a relief of 200-2500 ft. respectively. These rather high erosion rates are attributed to the high relief and annual precipitation common in Papua. Data from the La Caridad deposit (Saegart and others, 1974; Kilpatrick, 1970; J. D. Sell, 1974, pers. comm.) permit calculation (Appendix A) of the maximum range of erosion rates over the last 20 million years. The rates vary from 0.05-0.25 ft./1000 yr., a range close to the minimum rate calculated by Ruxton and McDougall. The Caridad rates, which were derived in such a way as to give minimum limiting values, are probably more applicable to Silver Bell because of similar climates over the last 20 m.y. Using a rate of 0.1 ft./1000 yr. for Silver Bell, because the present topography is more subdued and thus erosion is slower than at La Caridad, the time required to erode the last 400 ft. of rock at Silver Bell is

$$(\text{400 ft.})/(0.1/1000 \text{ yrs.}) = 4 \text{ million years}$$

The uncertainty in the numbers used deserves some comment. The grades of the capping, chalcocite blanket, and the protore are probably accurate to within 10% of the values used. The thicknesses of the capping and the chalcocite blanket are probably more variable, although the estimates used in the calculations are probably within 20% of the true values and are similar to values cited by Richard and Courtright (1954). The major variable used is the erosion rate; however, the value used in these calculations is near the lower limit calculated from two geographically different, but geologically similar, environments and is probably reasonable.

The estimate suggests that the erosion necessary to provide the observed supergene enrichment at Silver Bell occurred within the last 4 m.y. It is possible that the actual process required a longer period of time; however, the various approximations used in the calculations were selected so that the time estimate would be a maximum. In my opinion the estimate is reasonable and it lends further support to a concept of Late Tertiary supergene enrichment at Silver Bell.

Implicit throughout the calculations is the assumption that leaching of the capping which has since been eroded away was as efficient as the leaching process which formed the present capping. This is a reasonable assumption and, in fact, leaching of the eroded capping may have been more efficient because of a higher ratio of pyrite: copper sulfides in the earlier, lower grade chalcocite blanket.

Also implicit in the calculations is the assumption that there was no significant loss of copper from the deposit by lateral movement of copper-bearing groundwater. Lateral movement has demonstrably occurred at La Caridad (Saegart and others, 1974) and in the West Oxide deposit. However, drilling has yet to demonstrate that significant loss of copper through lateral migration has occurred either in El Tiro or Oxide pits. In contrast to the topography at Caridad and West Oxide, the centers of both the El Tiro and Oxide deposits underlay steeply incised gullies, a configuration which would have favored lateral movement of groundwater inward toward the center of the orebody. This would cause the enrichment factor to be higher than that due to simple vertical movement of groundwater and would result in calculation of a longer erosion cycle than actually occurred. Interestingly, the position of the gullies coincides with the thickest and highest grade portions of the chalcocite blankets.

I don't deny that some lateral movement of copper in groundwater occurred and that some copper was lost in this manner. However, this loss was probably insignificant judging from the scarcity of copper oxide zones outside the primary mineralization. Actually the largest copper oxide deposits in the area, the Daisy and the Copper Girl, were located within the present pit perimeters and resulted from deep oxidation along fault zones after withdrawal of the water table. I suspect that this oxidation was partly caused by the previous complete replacement of all hypogene sulfides by chalcocite. Thus, there was no pyrite left to form ferric iron leaching solutions at the top of the chalcocite blanket.

It is interesting that more porphyry copper deposits don't contain a high grade copper oxide zone capping the chalcocite blanket, Ajo and portions of the Miami orebody being the only ones of which I am aware. The absence of a copper oxide cap is obviously due to the presence of pyrite at the top of the chalcocite blanket in amounts sufficient to generate sufficient Fe^{+3} and H_2SO_4 to leach all the copper from the rock. This means that in most porphyry copper deposits the pyrite in the topmost portions of the chalcocite blanket was never completely replaced by chalcocite, although Ransome (1919) shows that the tops of the chalcocite blankets generally contain the highest grades of copper.

In many deposits the sulfides form 6-8 wt. % of the rock which, if completely replaced by chalcocite would yield copper grades of 5-6.5% Cu. Although grades in the upper parts of chalcocite blankets sometimes approach these levels, they rarely exceed the limit beyond which it would be impossible to leach all the copper in the rock. One reason for this might be due to a massive single stage of enrichment for the present blanket, as noted at Toquepala (Richard and Courtright, 1958) and also at Sar Cheshmeh. However, in most Arizona deposits, progressive enrichment is clearly indicated by the limonites. A second reason is possibly that enrichment in the Arizona porphyries is very recent, although this is clearly an overgeneralization as some chalcocite blankets such as in the Ray and Miami districts are very old. A third reason, the most probable, is that there were seasonal or cyclic (5-100 years) rises and drops in the water table such that when the water table was low, deep portions of the sulfide zone could be washed with cupriferous waters and in wetter times when the water table was high the upper part of the chalcocite blanket grew. This possibility does not conflict with earlier thoughts on a stationary water table because the deep cupriferous waters do not physically move upward during a wetter climatic cycle, but rather are buried by an influx of fresh, cupriferous water from the surface. Five to one hundred year cycles are relatively short in terms of destruction of preexisting hypogene sulfides which would probably show little or no effects of former oxidation. Copper sulfates derived from initial oxidation of chalcocite would be dissolved in the new meteoric water leaving no trace of their former presence. I think the cyclic movement of the water table in response to climatic fluctuations is the only way to:

1) prevent the top of the chalcocite blanket from becoming overloaded with chalcocite with the resulting formation of a high grade copper oxide zone between the chalcocite blanket and the leached capping, and

2) to enable cupriferous waters to reach deep into the sulfide zone in order to form a thick chalcocite blanket.

Some movement of cupriferous solutions to deeper portions of the sulfide column has undoubtedly occurred due to a constant outflow of water from the blanket into the surrounding basins. However, I suspect that this movement is slow and continuous rather than cyclic. Outflow of water from the base of the blanket is necessary to keep the deposit from becoming saturated to the surface, a phenomenon which would terminate enrichment. Implicit in this model is the concept that in situ chalcocite blankets will only be found in the present basins, where it can be shown they occurred at formerly higher elevations than the adjacent bedrock. In addition, these blankets will be much older than those at Silver Bell, possibly similar in age to chalcocite blankets in the Ray and Miami districts.

CONCLUSIONS

Several features have been observed in the Silver Bell district which suggest that the chalcocite blankets formed in the Late Tertiary. These include:

1) the equilibrium configuration of the present topography and the top of the chalcocite blanket,

2) evidence that enrichment in the West Oxide deposit occurred after emplacement of Mid-Tertiary andesite dikes, and

3) an estimate from erosion rates which suggests that enrichment could have occurred in the last 4 million years.

The clast lithology in the Cocio conglomerate was shown to be undiagnostic. These studies only pertain to the formation of the present chalcocite blankets. I don't deny that the sulfide system was exposed throughout the Tertiary and it is entirely possible that several chalcocite blankets may have been formed and subsequently destroyed. However, the present blankets are thought to have developed within the last 4 million years.

The possibility that some of the present chalcocite contains enriched copper of pre-Mid-Tertiary age is interesting, but this must be a very minor contribution. If this had been significant, then the question of where the copper in the rocks a few hundred feet above the present capping went must be answered -- this copper is not seen in areas surrounding the present orebodies. In addition it would have been a remarkable coincidence for conditions to change from rapidly eroding to efficient leaching just at the present ground surface.

There is evidence at Silver Bell that the present chalcocite blankets are being destroyed. This includes leached zones which penetrate deeply into the chalcocite zone along permeable joints and faults, the presence of copper sulfates which are common at the top of the chalcocite blanket, and(?) the presence of high grade zones of oxide copper within the chalcocite blanket. This destruction is probably related to the withdrawal of the water table to greater depths. The timing of this withdrawal is unknown, although it was probably a relatively recent event. I suspect that the destruction of the present blankets began 1,000-50,000 years ago, an interval which does not significantly alter the 4 million years estimated to form the chalcocite. Although we refer to this phenomenon as destruction, it may simply be continued enrichment of deeper portions of the chalcocite blanket during a drier climatic cycle.

Much of the foregoing is admittedly beyond the more immediate objective of ore finding. However, the relationship of enrichment factors to the total amount of copper in a complete porphyry copper system is relevant to further exploration for deposits such as those in the Whitetail conglomerate in the Superior East area, and a short report will be forthcoming on this aspect of Silver Bell geology.

F. T. Graybeal

F. T. Graybeal

FTG:lb
Attachs.

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APPENDIX A

EROSION RATES AT THE LA CARIDAD DEPOSIT, MEXICO

The La Caridad deposit was beheaded by the flat-dipping Caridad fault which displaced altered rocks high in the column approximately 2.5 miles to the northeast. One dip was mapped at 40° and Kilpatrick (1970) suggests from observations of bends in the outcrops of the fault that dips may be as low as 25°. Projection of these dips to the northeast place the fault about 2000 ft. below the Caridad Antigua mine which is interpreted as a high-level slice of the hydrothermal column. The presence of tourmaline breccias, alunite, enargite, tetrahedrite(?), barite, and fluorite in the Caridad Antigua area is consistent with this interpretation.

The hangingwall of the Caridad fault also contains a post-mineral conglomerate which includes a rhyolite flow dated at 24 m.y. The fault cuts the conglomerate, thus dating movement at less than 24 m.y. The Caridad conglomerate contains a few clasts of limonite after chalcocite (Saegart and others, 1974, p. 1071), which are not widespread (J. D. Sell, 1974, pers. comm.). Saegart and others believe that the clasts indicate that chalcocite enrichment began more than 24 m.y. ago.

I would agree that some enrichment may have occurred prior to deposition of the Caridad conglomerate, although I would comment that limonite after enargite appears quite similar to limonite after chalcocite. However, I would dispute the presence of a significant amount (more than 5%) of the pre-Caridad conglomerate chalcocite copper in the present day chalcocite blanket. It is notable that significant limonite after chalcocite and observed chalcocite enrichment are rare in the Caridad Antigua mine area. In addition the Caridad fault lies roughly 2000 ft. beneath the Caridad Antigua mine and from 200-1500 ft. below the strongly tourmalinized zones south of the mine. Therefore if chalcocite was left behind after faulting the blanket would have extended more than 1000 ft. below the Caridad Antigua mine area, a depth I feel is unreasonable. Also notable is the relatively low abundance of clasts containing indigenous hematitic limonite, presumably after chalcocite (less than 5 percent according to J. D. Sell, 1974, pers. comm.). Finally, the conformable geometry of the top of the chalcocite blanket and the present topography indicate that enrichment has been influenced by modern erosion. Cross-sections of the orebody indicate incipient destruction of the blanket at the present time.

The above considerations indicate that the bulk of the enrichment in the present orebody occurred after the deposit was beheaded by the Caridad fault. Movement on the fault occurred within the past 24 m.y. and I will use 20 m.y. as the time when the hangingwall had moved far enough or erosion had cut deeply enough through it so that erosion and enrichment of the deeper portions of the mineralization could again begin.

In order to calculate the amount of rock eroded from the deposit, the enrichment factor (grade of chalcocite blanket/grade of protore) must be known. Saegart and others (1974) state that the enrichment factor at La Caridad is about 3.5. This means that a thickness of rock equivalent to at least 2.5 times the thickness of the chalcocite blanket has been leached and that this leached copper has been added to the protore. The assumptions requite that the hypogene grade be relatively uniform and that all the hypogene copper is leached and added to the chalcocite blanket. The influence of variations in these assumptions on the calculations will be discussed below.

Constants used in the calculations are as follows:

enrichment factor = 3.5
length of enrichment cycle = 20 million years

Assumptions must also be made for the average thickness of the chalcocite blanket and the leached capping. These thicknesses are somewhat variable at La Caridad and, therefore, several sets of values were used as follows:

1) average values for the entire deposit (from Saegart and others, 1974);
   leached capping = 165 ft.
   chalcocite blanket = 300 ft.

2) maximum values for the deposit (from Saegart and others, 1974);
   leached capping = 660 ft.
   chalcocite blanket = 825 ft.

3) average values from within the area of moderate to strong alteration (average of about 30 measurements from cross sections in Kilpatrick, 1970);
   leached capping = 250 ft.
   chalcocite blanket = 450 ft.

The different sets of values were selected to provide an estimate of the influence of these variations on the final calculation. Saegart and others mention that a possibly significant amount of lateral migration of copper outward from the core of the deposit may have occurred and, thus, average values for the entire deposit may be misleading. I have included the data in set 3 for this reason. Average values for minimum thicknesses appear to be nil.

The calculation of the erosion rate proceeds as follows:

$$\frac{\left[(t_{cc}E)-t_{cc}\right] - t_{cap}}{T} = \text{erosion rate (ft./1000 yrs.)}$$

where

t_{cc} = thickness of the chalcocite blanket
E = enrichment factor
t_{cap} = thickness of present leached capping
T = length of enrichment cycle.

The results of the calculations for the three sets of data yield the following erosion rates:

1) 0.029 ft./1000 yrs.
2) 0.070 ft./1000 yrs.
3) 0.044 ft./1000 yrs.

Several aspects of these calculations indicate that the erosion rates are probably minimum values. In this calculation, the copper contained in the eroded capping fragments, which probably averaged 0.03% Cu, was not inventoried. In addition the evidence for lateral migration of copper out of the deposit is strong. In both instances if allowances for these losses had been made the enrichment factor would have been increased resulting in more rapid erosion rates than were calculated. Finally, the high local relief in the area suggests that current erosion rates may be considerably more rapid than those calculated from the enrichment factor. In view of the many uncertainties in this type of calculation, I think the results are in reasonable agreement and, as an average value, I will use 0.05 ft./1000 yrs. as the minimum erosion rate at La Caridad.

A maximum rate may be inferred by projecting the Caridad fault at a 40° dip to the southwest. This surface passes over the center of the La Caridad deposit about 5000 ft. above the present surface. Erosion of 5000 ft. of rock in 20 m.y. requires an average rate of 0.25 ft./1000 yrs.

Given a reasonably accurate set of basic assumptions it can be calculated that the erosion rate at the La Caridad deposit has averaged somewhere in the range 0.05-0.25 ft./1000 yrs. The assumptions involving enrichment factor, thickness of the chalcocite blanket and leached capping, and continuity of the hypogene mineralization are all reasonable and variations in them do not affect the calculations by more than 50 percent. The assumption that the deposit was beheaded by the Caridad fault less than 24 m.y. ago appears to be generally accepted by all workers familiar with the deposit. If the length of the enrichment cycle was less than 20 million years, then the erosion rates are too low.

The comment by Saegart and others (1974) that enrichment occurred over "an extended Mid-Tertiary time interval" appears wholly based on the few clasts observed in the Caridad conglomerate and the oversimplified observations by Livingston and others (1968) that most of the presently observed enrichment in the Arizona porphyry copper deposits was developed prior to deposition of Mid-Tertiary volcanic and sedimentary rocks. I do not dispute the statement that enrichment at La Caridad may have started more than 24 m.y. ago; however, there is no evidence that this assumed enrichment cycle was of long duration, that it resulted in a substantial enrichment factor, or that any of this hypothetical enrichment was left behind in the footwall of the Caridad fault.

The two estimates of erosion rates at La Caridad are based on the concept that the La Caridad deposit was beheaded by the Caridad fault about 20 m.y. ago and that more than 90 percent of the observed enrichment occurred since then. The calculations were performed in such a way that the estimate of 0.05 ft./1000 yrs. is a minimum and the estimate of 0.25 ft./1000 yrs. is a maximum for a 20 m.y. enrichment cycle. Considering the nature of the problem, the uncertainty in some of the assumptions, and the fact that calculations such as these are generally order of magnitude estimates, I think that the agreement of the two estimates are quite good, particularly since they were derived so that a maximum range of erosion rates would result. It is my opinion that the enrichment cycle used in the calculations is also a maximum and that the actual length of this cycle could be much less. Thus, the calculated erosion rates may be low by an unknown factor.

AMERICAN SMELTING AND REFINING COMPANY
ASARCO
EXPLORATION DEPARTMENT
P.O. BOX 5747, TUCSON, ARIZONA 85703

J. H. COURTRIGHT
CHIEF GEOLOGIST

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

November 19, 1974

Mr. R. W. Hodder
Associate Professor
The University of Western Ontario
London, Canada

Dear Bob:

I have your letter of November 11 regarding the Arizona field excursion planned for next month. Fred Graybeal and I will both be glad to take part in two days of the tour.

Arrangements have been made to visit Silver Bell on Tuesday, December 17, meeting at our office here in Tucson at 8:00 A.M., as we did last year. Jim Galey, resident geologist will conduct the tour. Lunch at mine mess hall for plus or minus 23 persons.

The Twin Buttes-Sierrita-Mission reconnaisance on Wednesday, December 18 will be similar to that of last year. An itinerary prepared by Fred is enclosed. Lou Jannsen, Mission geologist, will meet us at the mine overlook.

We will pray for "Chamber of Commerce" type weather and look forward to meeting the members of your group.

Yours truly,

J. H. Courtright

J. H. Courtright

JHC:vmh
Enclosure
cc: JJCollins w/o enc.
WLKurtz w/o enc.
FTGraybeal w/o enc.

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

July 26, 1974

J. H. C.

AUG 8 1974

FILE MEMORANDUM

Silver Bell District
Pima County, Arizona

Freeport Minerals hired Kenyon Richards to review with them and Jim Briscoe Briscoe's ideas of the extension of the Silver Bell alteration zone (offset to the south along the "cemetary fault"). Apparently Kenyon is more intrigued with the idea now than he was a number of years ago.

When they discovered our NWS claims, Briscoe couldn't believe anyone would stake that ground for mineral potential. Kenyon was non-committal.

W. L. Kurtz

WLK:lb

cc: JHCourtright
FTGraybeal
JDSell

ASARCO

AMERICAN SMELTING AND REFINING COMPANY
ROCKY MOUNTAIN EXPLORATION DIVISION
1805 SOUTH BELLAIRE STREET. DENVER. COLORADO 80222

TELEPHONE 303-757-5107

RECEIVED
JUN 18 1973
EXPLORATION DEPT.

June 14, 1973

J. H. C.
JUN 18 1973

file
Silver Bell

Dr. Fred Graybeal
American Smelting and Refining Company
P.O. Box 5747
Tucson, Arizona 85703

Dear Fred:

Enclosed is your copy of Barry Watson's report and map of the East Silver Bell area. Thanks for allowing me to borrow it. The report and map seem to be very good; however, I do find local plotting errors due to the distortion which is inherent with his air photo base used for mapping. In addition, there is little if any attempt to unravel the alteration toward the east although Harold Courtright's 1948 alteration map agrees well with what little I have observed up to the 30,000E coordinate. I have only spent three hours in the area with Mr. Cameron during my "last" day at Silver Bell, therefore I do not have a good total picture of the region. However, based on the only maps made available to me, it seems that additional 1"=200 ft. scale mapping may be in order for the area for several reasons.

It seems that recent theories that you have developed along West Oxide Pit concerning the lateral-downward migration and deposition of copper along post-mineral dikes may also apply in the east Portland Ridge area. In this area currently being drilled, Tertiary quartz latite dikes cut syenodiorite in the region bounded by coordinates 28,000N, 29,000N and 29,000E, 30,000E. Cored fracture zones within the post mineral dikes contain minor copper carbonates and locally up to two inches away from the fractures feldspars have been "soaked" with green copper carbonates. Unlike the late andesite dikes, these post mineral dikes do not retain or "dam up" much migrating copper. Capping in the area is generally poor and yet one hole cut +80 feet of .90% Cu in syenodiorite. Interestingly enough, on the slopes in a topographic saddle (29,500N; 29,500E) above this hole the capping is good as was recorded by Mr. Courtright in 1948. In any event, map coverage should be updated in this presumably rather gray area of coverage and also extended through the East Silver Bell area. I think this map updating using your quite valid new alteration mapping approach (re: Cummings March 1973 Report) and also implimenting your thoughts on copper migration at Silver Bell could prove of more than just academic interest for the area.

Mr. Courtright was interested in the appearance of the post mineral quartz latite dikes in the East Portland Ridge area (abundant quartz? phenocrysts) and the possibility that several earlier churn drill holes may have cut similar barren dikes as was done with the current drilling in the East Portland area. Due to lack of time, a very cursory examination was made of two of the (F-Series) and three other core boards. Of significance is the fact that hole #186 cut latite dike from 35-205' thus cutting out a significant portion of a possible supergene blanket. In addition, the F-1 and F-5 holes that I scanned did not appear to contain any post mineral dike material but 75% of the cuttings have fallen off the boards due to some rather unstable glue. I think the majority of the (F-Series) core boards could be saved and reglued. In any event the remaining F-Series holes should be checked to confirm whether or not post mineral dikes were encountered. If so additional reserves could be found by offsetting these holes or using a closer spaced (than +400 Ft.) grid of new holes.

Two days before I left Silver Bell I spent four hours touring the North Silver Bell area. In this area it seems that additional mapping may be in order, also. Although large areas of poor capping were observed, better capping areas seem to be found in outcrops along the drainages which may or may not be a proper observation. But if this is the case, is there some additional leaching mask that would render areas of higher relief to develop poorer capping? The map made available to me for this area was a composite that Mr. Cameron made from Messrs. Schmitt's, Mitchem's and Evans' data at a 1"=1000' scale. That scale just seems inadequate to me. I understand from Mr. Bob Barnes that a new topo base will be prepared soon that would cover the blank area of North Silver Bell toward the northeast from Sections 3, 33, 34, 27, 28, etc. With a new base and a better scale, much could be learned, again applying your new thoughts toward updating alteration and structure.

Two additional thoughts about the geology at Silver Bell have been on my mind for some time. First, although daily mapping records structure (mineralized and unmineralized fractures and faults) little if anything additional is done with the data after, except to include it on a larger quarterly mylar. In addition, I found that during my stay I recorded more unmineralized fractures for similar pieces of toe than did the resident geologist. I'm not sure whether this fact is readily important or not and I'm not positive about what could be done with that structural data except possibly projecting trends. But it seems to me that in an area where ore is found as a function of structure, something more could be done with recording and evaluating that structure.

My second thought pertains to the significance of different appearing quartz monzonite dikes. I realize Mr. Kerr and others have recognized a petrographic and perhaps megascopic difference, previously. I can only suggest that it seems to me that there is a definite megascopic difference in texture and mineralogy between quartz monzonite dikes from an area I mapped north of the Oxide Pit where no ore is found, to those monzonite dikes within the Oxide Pit, and to those in the Imperial area of El Tiro, or those in El Tiro Pit. These megascopic differences are probably related to differing types and degrees of alteration but it seems also possible that such differences could be related to the wall rock chemistry of differing hosts as well. I'm only questioning which type if any could aid in finding additional reserves.

I realize you probably have thought about these aspects before this but I just wanted to bring to light a few of the many puzzling thoughts on the geology at Silver Bell.

Thanks again for all your help.

Very truly yours,

Chuck

C.E. Beverly

Enclosure
cc. J.H. Courtright, without enclosure
S. Von Fay, without enclosure

ASARCO

AMERICAN SMELTING AND REFINING COMPANY
ROCKY MOUNTAIN EXPLORATION DIVISION
1805 SOUTH BELLAIRE STREET. DENVER. COLORADO 80222
TELEPHONE 303-757-5107

RECEIVED
JUN 8 1973
EXPLORATION DEPT.

June 6, 1973

J. H. C.
JUN 8 1973

Mr. J.H. Courtright
Chief Geologist
American Smelting and Refining Company
P.O. Box 5747
Tucson, Arizona 85703

Dear Harold:

I wish to express my appreciation and thanks to you and (by copy of this letter) to Mr. Collins for giving me the opportunity to work at Silver Bell. I feel that the Silver Bell program has been a very worthwhile and rewarding experience for me. The exposure to all aspects of the operation has enhanced my concepts of mining requirements and production problems. Of most benefit to me and coincident with my interests was detailed mapping within both pits and a fringe area north of the Oxide pit. This experience has not only acquainted me with the subtle geologic aspects of the ore zones but it has sharpened my mapping techniques in terms of recognizing and recording alteration and mineralization assemblages. This aspect will certainly aid in my effectiveness as an exploration geologist.

In addition, the cooperation and help that Mr. Kurtz and his staff were willing to give has been one of the most valuable assets of the entire program and certainly assured its success. By being exposed to such a group of dedicated geologists I have gained invaluable knowledge concerning a fresh approach to exploration. In my opinion his staff's ability and dedication is second to none.

The total Silver Bell program has been a very beneficial one for me. John King and I are currently compiling a joint memo concerning both programs which will hopefully strengthen such efforts in the future.

Very truly yours,

Chuck

C.E. Beverly

cc. J.J. Collins

ASARCO

AMERICAN SMELTING AND REFINING COMPANY
ROCKY MOUNTAIN EXPLORATION DIVISION
1805 SOUTH BELLAIRE STREET. DENVER. COLORADO 80222

RECEIVED
JUN 8 1973
EXPLORATION DEPT.

June 6, 1973

TELEPHONE 303-757-5107

J. H. C.
JUN 8 1973

Mr. W.L. Kurtz, Supervisor
American Smelting and Refining Company
P.O. Box 5747
Tucson, Arizona 85703

Dear Bill:

I want to express my appreciation to you and your staff and in particular Jim Sell, Fred Graybeal and Bob Crist for the guidance, support and time that you were willing to give to me throughout the Silver Bell program. I believe that the Silver Bell program is a very worthwhile one that hopefully will be continued for others to benefit and enjoy.

As I have expressed to you previously, I feel that one of the most beneficial aspects of the program has been the close association with your office, the various mine tours that you arranged, and the many fruitful discussions that I have enjoyed with your group.

I have never been associated with a more dedicated group of geologists. Your positive approach to exploration is a refreshing one, the standard of which I hope to maintain in the years ahead. Personally, I cannot thank you enough not only for helping me but for supporting our exploration program here in Denver and thus rejuvenating an otherwise rather standard exploration effort. Your efforts on this behalf are most appreciated.

Best regards for a successful and happy summer.

Very truly yours,

Chuck

C.E. Beverly

cc. J.H. Courtright
J.J. Collins

ASARCO
AMERICAN SMELTING AND REFINING COMPANY
ROCKY MOUNTAIN EXPLORATION DIVISION
1805 SOUTH BELLAIRE STREET. DENVER. COLORADO 80222

RECEIVED
JUN 8 1973
EXPLORATION DEPT.

June 6, 1973

TELEPHONE 303-757-5107

J. H. C.
JUN 8 1973

Mr. J.W. Cameron
Resident Geologist
American Smelting and Refining Company
Silver Bell, Arizona 85270

file

Dear Whit:

I would like to express my appreciation to you for all your help during my stay at Silver Bell. The program at Silver Bell was an especially rewarding experience for me. Although my interests were geared toward mapping, I did enjoy the exposure to all aspects of the resident geologist's duties.

Personally, the mapping in both pits utilizing the Silver Bell system was most beneficial to me in terms of recognizing and understanding some of the more subtle aspects of the ore and related alteration.

I do appreciate your spending the last two days of my visit showing me the North Silver Bell and East Silver Bell areas. Perhaps, if time had been available I would have liked to map within one of these fringe zones, just to compare it with what I had learned from the ore zones.

Thanks again.

Best regards,

Chuck

C.E. Beverly

bcc. J.H. Courtright
W.L. Kurtz

ASARCO

AMERICAN SMELTING AND REFINING COMPANY
ROCKY MOUNTAIN EXPLORATION DIVISION
1805 SOUTH BELLAIRE STREET. DENVER. COLORADO 80222

TELEPHONE 303-757-6107

RECEIVED
JUN 8 1973
EXPLORATION DEPT.

June 6, 1973

J. H. C.
JUN 8 1973

Mr. D.L. Jameson
Superintendent
American Smelting and Refining Company
Silver Bell, Arizona 85270

Dear Mr. Jameson:

I wish to express my appreciation and thanks to you for allowing me the opportunity to work at Silver Bell for the past five months.

The experience of getting involved with nearly all phases of the operation has been a rewarding one for me.

I now have a better framework of ideas concerning mining requirements and problems associated with maintaining production and development. In addition, through geologic mapping within both pits I have been able to gain valuable experience concerning the many geological aspects related to ore at Silver Bell.

The experience I gained from the Silver Bell program has been most beneficial and it will greatly aid me in my future exploration work for ASARCO. Thanks again to you and your staff for the hospitality shown me during my stay at Silver Bell.

Very truly yours,

C. E. Beverly

C.E. Beverly

bcc. J.H. Courtright
W.L. Kurtz

Silver Bell

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

May 8, 1973

MEMORANDUM FOR: D.E. CROWELL

COMPARISON OF SILVER BELL
AND SACATON ORE BODIES

Reference is made to your letter to Mr. Kurtz of May 1st, regarding permeability tests to be conducted to acquire data useful in the design of the Sacaton tailings disposal system.

Excepting the tactite ore in the Imperial area, the Silver Bell and Sacaton deposits are in general similar in respect to rock types, mineralization, and alteration. Supergene chalcocite enrichment is present in both with the strongest development of clay minerals occurring in the upper part of the chalcocite blankets. The clay content progressively decreases downward and reaches a minimum in the relatively low grade primary mineralization. The clay is largely supergene, being formed by the effect of acid (from oxidation of pyrite) on rock minerals such as feldspar. Clay is (or was) somewhat more abundant in the Oxide due to the higher pyrite content as compared to El Tiro. However, the average pyrite content should be approximately equivalent to that of Sacaton.

Although the amount of tactite ore mined from El Tiro was relatively small, it might have had some effect on the permeability of the tailings of No. 2 dam.

J.H. Courtright
J.H. COURTRIGHT

JHC:kre

cc: J.J. Collins w/encl.
R.B. Meen w/o encl.
W.L. Kurtz w/o encl.

RECEIVED
MAY 1 1973
S. W. U. S. EXPL. DIV.

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

May 1, 1973

Mr. W. L. Kurtz
Building

Comparison of Silver Bell
and Sacaton Ore Bodies

Dear Mr. Kurtz:

We are currently engaged in a study of the proposed Sacaton tailing disposal system. Of particular interest is the permeability of the layers of tailing after the tailing has been deposited. Since we do not have the actual Sacaton tailing to work with, we intend to test the tailing dams at Silver Bell with regard to permeability, size gradation, etc.

It is our understanding that the Silver Bell ore is similar to that at Sacaton but we need a geological opinion regarding these two ore bodies. If possible, we would like to have a statement from the Exploration Department comparing the Silver Bell and Sacaton ore bodies and confirming that they are basically similar as regards rock type and degree of alteration. We can then safely use Silver Bell test data to predict the characteristics of the Sacaton tailing dam.

I believe that the ore mined at Silver Bell has changed somewhat over the years so time of mining would also be a factor. We have two Silver Bell tailing dams which can be tested; the No. 1 dam received most of the tonnage milled from start up through the late nineteen sixties and the No. 2 dam received the tonnage milled since that time.

Yours truly,

D. E. Crowell

DEC:db

cc: RBMeen

S-10.10

ASARCO

AMERICAN SMELTING AND REFINING COMPANY
SOUTHWESTERN MINING DEPARTMENT
P. O. BOX 5747, TUCSON, ARIZONA 85703

R. B. MEEN
MANAGER
ROY S. HERDE
ASSISTANT MANAGER

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

January 15, 1973

J. H. C.
JAN 15 1973

Silver Bell

Mr. Edward Krish
61 Prospector Village
Golden, Colorado 80401

PUBLICATION OF THESIS DATA

Dear Mr. Krish:

Further to my letter of January 11, 1973 regarding the publication of data you have compiled at our Silver Bell Unit, we would like to review the content of your thesis before it is submitted to the Colorado School of Mines for approval. Would you please send us a copy when you have completed it.

Thank you for your cooperation in this matter.

Very truly yours,

Roy S. Herde

ROY S. HERDE
Assistant Manager

nb

bcc: WKMurray)
JHCourtright)
WLKurtz)
DRJameson)

Blind note to W. K. Murray:
Mr. Kurtz has requested that we review the report, as per his note, copy of which is attached.

S-10.10

AMERICAN SMELTING AND REFINING COMPANY
SOUTHWESTERN MINING DEPARTMENT
P. O. BOX 5747, TUCSON, ARIZONA 85703

ASARCO

J. H. C.

JAN 12 1973

R. B. MEEN
MANAGER
ROY S. HERDE
ASSISTANT MANAGER

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

January 11, 1973

Silver Bell

Mr. W. K. Murray, Director
Advertising and Public Relations
American Smelting and Refining Company
120 Broadway
New York, New York 10005

PUBLICATION OF THESIS DATA

Dear Bill:

Enclosed is a copy of a letter from one Edward Krish, requesting a release for information that he has gathered at Silver Bell for his thesis.

Last September Harold Courtright asked permission for this young man to conduct a study which would involve analytical work for trace elements on the capping and underlying sulphides at Silver Bell. In the interests of good public relations with the Colorado School of Mines, this permission was granted, and the young man did the above-outlined work in November of 1972.

Would you please give to him directly or to me, as you choose, some guidelines as to the manner in which he may use the information.

Very truly yours,

Roy S. Herde

ROY ~~S.~~ HERDE
Assistant Manager

RSH:nb

Encl.

cc: JHCourtright - w/encl.
WLKurtz - " "
DRJameson - " "

R. S. H.

JAN 10 1973

61 Prospector Village
Golden, Colorado 80401
8 January 1973

Mr. Roy S. Herde
Assistant Manager
American Smelting and Refining Co.
P.O. Box 5747
Tucson, Arizona 85703

Dear Mr. Herde:

During the first two weeks in November 1972 I conducted field work at the Silver Bell Unit for my thesis project.

Before I can continue working on my thesis I need a short letter from ASARCO concerning the release of information that I gather and analyze for my thesis. Could you please write me such a note or forward my request to whomever handles these matters.

Thank you for your help in this matter.

Sincerely,

Edward Krish

Edward Krish

S-10.10

AMERICAN SMELTING AND REFINING COMPANY
SOUTHWESTERN MINING DEPARTMENT
P. O. BOX 5747, TUCSON, ARIZONA 85703

R. B. MEEN
MANAGER
ROY S. HERDE
ASSISTANT MANAGER

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

January 11, 1973

Mr. Edward Krish
61 Prospector Village
Golden, Colorado 80401

PUBLICATION OF THESIS DATA

Dear Mr. Krish:

Thank you for your letter of January 8, 1973, requesting a release for the publication of the thesis data which you have gathered at Silver Bell.

We have forwarded a copy of your letter to Mr. W. K. Murray, Director of ASARCO's Advertising and Public Relations Department in New York, and requested some guidelines in regard to the Company's policy on releasing such information as you have compiled at Silver Bell. You should be hearing shortly, either from Mr. Murray directly or from me, in regard to this matter.

Very truly yours,

Roy S. Herde

ROY S. HERDE
Assistant Manager

RSH:nb

bcc: WKMurray
JHCourtright
WLKurtz
DRJameson

J. H. C.
FEB 6 1973

AMERICAN SMELTING AND REFINING COMPANY
SILVER BELL UNIT
Silver Bell, Arizona

January 2, 1973

MEMORANDUM TO: Mr. D. R. Jameson, Superintendent

Subject: GRAVITY SLIDE POTENTIAL IN NORTH SILVER BELL.

Data collected in the past several years have yielded evidence that an economically significant gravity slide may have occurred in North Silver Bell. An area with horizontal dimensions greater than 3500 by 2500 feet is indicated. It is reasonable to assume that the gravity slide area was enriched by supergene activity similar to that in El Tiro and Oxide pit areas prior to denudation by gravity sliding.

FIELD EVIDENCE AND FACTS:

Field evidence and porphyry copper zoning facts that have become available during the past several years includes:

1. Hydrothermal phyllically altered areas at Silver Bell have remained as topographic highs, relative to their adjacent areas.

2. Potassic alteration occurs at the surface of bedrock in the central part of North Silver Bell with a horizontal extent of 3500 x 2500 feet. Available data suggests continuation of the potassic envelope to a substantial distance west of drill hole D-320 (drilled 9/22, shown on Plates I and II). what data?

3. This potassically altered area is topographically low lying with no topographic highs surrounding it except to the east.

4. There should have been a phyllically altered envelope enclosing the potassic envelope. The areas containing this phyllic alteration should have remained as a topographic high if erosion in this area was comparable to the norm at Silver Bell.

5. Any preexisting topographic high with phyllic alteration in the North Silver Bell area has been removed, producing a tilted, semi-dished shaped terrain 300 to 500 feet lower than the expected "average" elevation.

GRAVITY SLIDE POTENTIAL IN NORTH SILVER BELL - 1/2/73

HYPOTHESES

There are two immediate explanations for this lower than "average" topography or greater than "average" denudation in the phyllically altered areas in North Silver Bell.

1. The phyllically altered area could have been removed by general erosional processes.

2. Pre-existing topographic high areas could have been removed by a gravity slide to the west/northwest.

DISCUSSION OF HYPOTHESES

Criteria opposing hypotheses #1 (erosional processes):

1. There is no substantial enrichment as might be expected in an area with protore values similar to the El Tiro and Oxide pit areas.

2. The topography in the North Silver Bell potential gravity slide area has a very low relief, with a 3 or 4 percent drop to the northwest.

3. Very rapid erosion without enrichment in a phyllically altered rock is not the rule in other Silver Bell areas.

Criteria supporting hypotheses #2 (gravity sliding):

1. High protore grades across an extensive area.

2. Generally low relief.

3. Generally lower topographic elevations.

4. Potassic with partially surrounding phyllic alteration at the surface of bedrock.

5. No substantial enrichment.

GENERAL DISCUSSION

Plates I, II and III show the copper values, alteration types and topography, respectively, in North Silver Bell.

Plate IV is a geologic map after O. D. Evans (1954). Evans mapped several areas of strongest mineralized joints. These areas represent the eastern extent of the phyllic halo around the potassic core. As shown on Plate IV, no phyllic alteration halo was noted to the west and the copper mineralization there was called "weak to absent". This "Weak to absent" area actually represents the potassic core. This zonal correlation apparently went un-noticed by Evans and is the key to the central theme of this report. ?

GRAVITY SLIDE POTENTIAL IN NORTH SILVER BELL - 1/2/73

DISCUSSION OF HYPOTHESES (Continued)

The western extent of the North Silver Bell hydrothermal envelope is not apparent. From available geological information (see plate II and IV), the western extent of the hydrothermal envelope should contain alaskite as an important wall rock. The alaskite in the El Tiro pit is a more favorable host rock than the dacite which consistently occurs along the eastern side of the District Fault. Therefore, the unexposed western limit of the hydrothermal envelope in North Silver Bell should have had more intense phyllic alteration and should contain better copper values than the eastern portion of this envelope which generally contains dacite as the main host rock.

There is no definite transition from potassic to lesser grades of alteration in a direction extending westward across the central mass as indicated on Plate II and Profile I. Protore values range from 0.2 to o.35 percent copper across the central mass with similar grades occurring in the most northwestern drill hole (D-320).

Enrichment should have taken place before gravity sliding occurred, if North Silver Bell had an erosional cycle similar to other parts of the Silver Bell District. Tonnages and grades would possibly be similar to the El Tiro and Oxide pits. Minimum thickness of the hydrothermal envelope above the potential gravity slide surface is on the order of 2,000 feet and could attain an actual thickness several times this value.

A distracting hypotheses is that the west Silver Bell mountains could conceivably represent a plate that slid off the North Silver Bell area. If this is the case, and if there was not a second plate which later slid off (the plate generally discussed above), then economic enrichment is unlikely. Multiple plates may be involved, of which the west Silver Bells would represent the upper plate and any lower plate(s) would possibly have undergone enrichment.

If there has been a gravity slide which has removed the upper part of the alteration envelope, direction of transport probably was west/northwest as indicated on Plate III. Several minor areomagnetic and gravity anomalies occur in sections 19, 29 and 30 (T.11S., R.8E) which are of possible interest. These anomalies probably should be detailed. Gravity slide-plate cover could include later Tertiary gravels and basalts. Detailed I.P. and resistivity surveys could be of assistance since post slide cover may be relatively thin.

SUMMARY

Based on the following field evidence, there is a reasonable potential for occurrence of a gravity slide in North Silver Bell, with the removed plate having been enriched before sliding occurred (i.e. - gravity sliding occurred after the main enrichment cycle at Silver Bell).

1. Low relief of the outcrop areas.

2. Lower topography than the expected "average".

SUMMARY (Continued)

3. A large outcrop area with potassically altered rock partially surrounded by a phyllic alteration zone.

4. Moderately high protore values of the central outcrop area.

5. Lack of expected enrichment in the outcrop area.

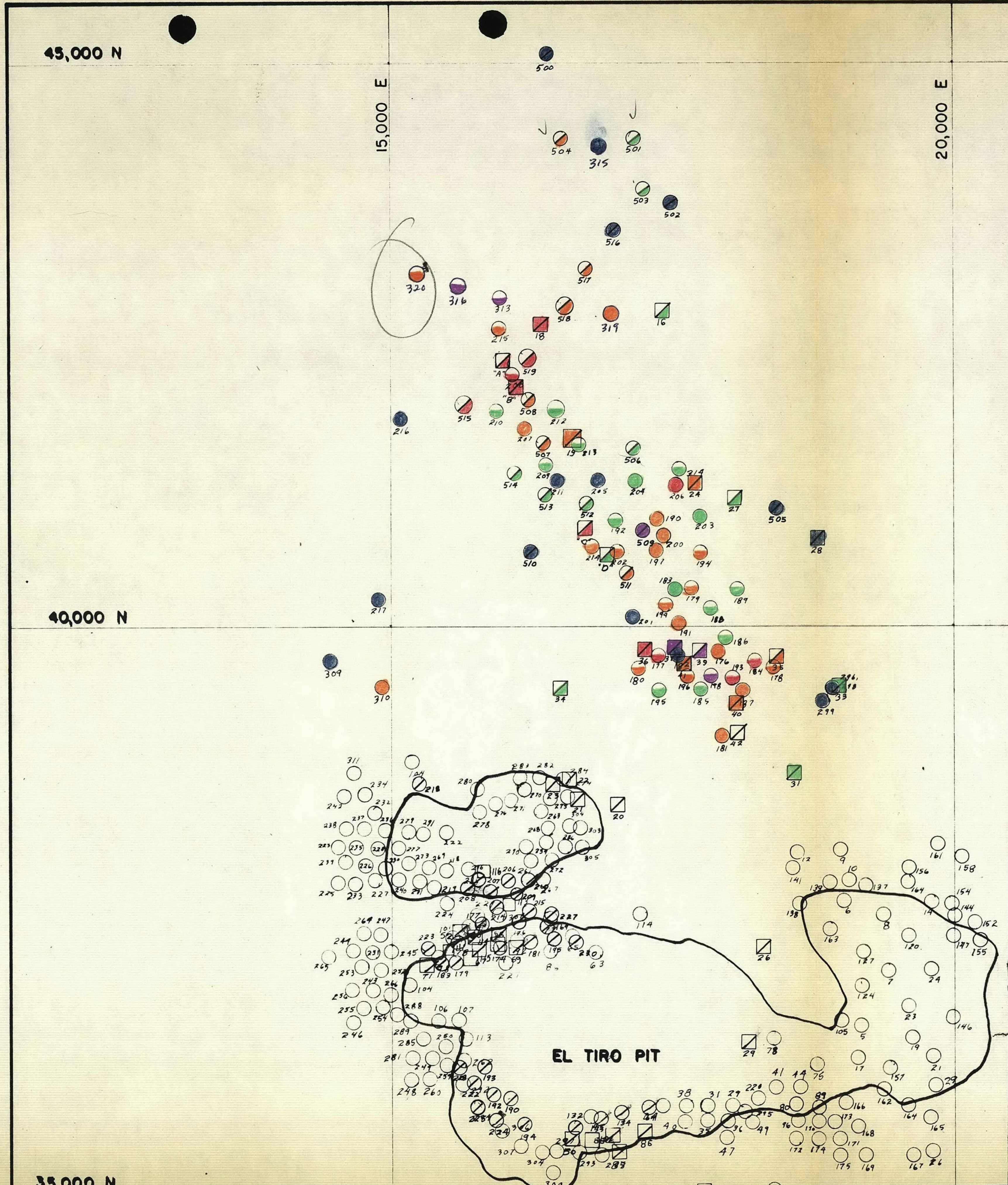
6. There is no adjacent alluvial valley of sufficient volume to be compatiable with denudation by general erosional processes.

Investigation of this hypotheses may provide additional economic reserves at an opportune time for the Silver Bell Unit. The mineral rights for the involved ground may or may not be open, see Plate IV.

J.W. Cameron

Jon W. Cameron
Resident Geologist

JWC:jca
Attachs.(5)
cc: RBMeen
JHCourtright
WLKurtz
File



LEGEND

□	DDH	101-120	EL TIRO
○	"	D-1-314	" "
⊘	CDH	E-121 - 230	
⊠	"	PRE - 1911	

○ ALL OR MOST INTERVALS

⊖ " " " "

UPPER INTERVALS

LOWER "

●	≥ 3	BENCHES	OF	≥ 0.7	% TOTAL CU.	
◒	" 3	"	"	0.4-0.7	" " ".	
●	" 2	"	"	≥ 0.7	" " ".	
◒	" 2	"	"	0.4-0.7	" " ".	
●	" 1	"	"	≥ 0.7	" " ".	
◒	" 1	"	"	0.4-0.7	" " ".	
●	< 1	"	"	≥ 0.7	" " ".	
◒	" 1	"	"	0.4-0.7	" " ".	
●	< 10 FEET	"		≥ 0.4	" " ".	

⊙ HIGH OXIDE CU IN SOME OR ALL INTERVALS.

ALTERATION

○ PROPYLITIC

○ ARGILLIC

○ PHYLLIC

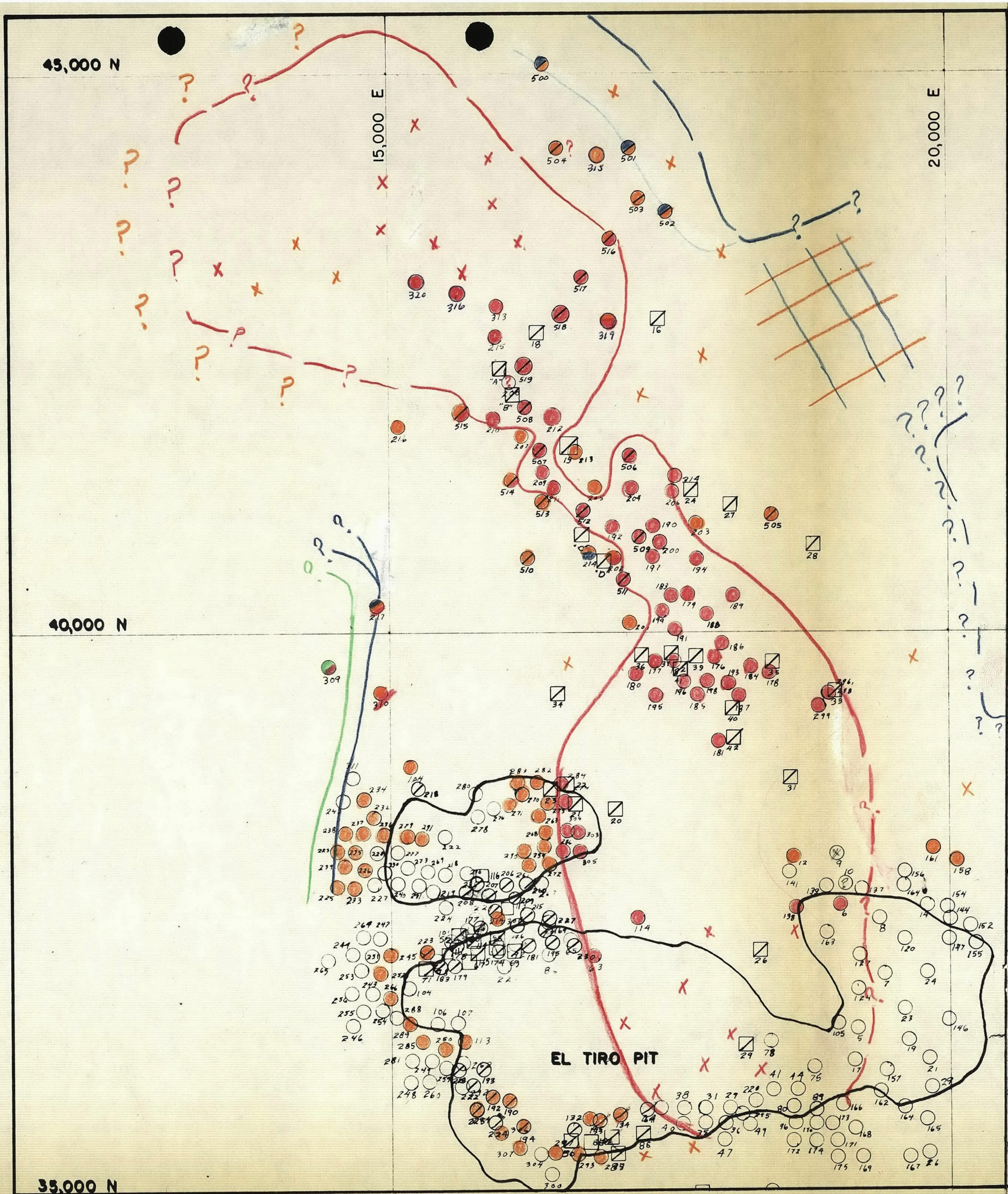
○ POTASSIC

GEOLOGIC REPORT
Date 1/2/73 By JWC
Att. # Plate I

AMERICAN SMELTING AND REFINING CO.
SILVER BELL UNIT

NORTH SILVER BELL
DRILL HOLE LOCATION MAP

1:12,000	JWC	8-72	S-11-11-C



LEGEND

DDH	101-120	EL TIRO
"	D-1-314	" "
CDH	E-121 - 230	
"	PRE - 1911	

ALL OR MOST INTERVALS

" " " "

UPPER INTERVALS

LOWER "

≥ 3	BENCHES	OF	≥ 0.7	% TOTAL	CU.	
" 3	"	"	0.4-0.7	"	"	".
" 2	"	"	≥ 0.7	"	"	".
" 2	"	"	0.4-0.7	"	"	".
" 1	"	"	≥ 0.7	"	"	".
" 1	"	"	0.4-0.7	"	"	".
< 1	"	"	≥ 0.7	"	"	".
" 1	"	"	0.4-0.7	"	"	".
< 10 FEET		"	≥ 0.4	"	"	".

HIGH OXIDE CU IN SOME OR ALL INTERVALS.

ALTERATION

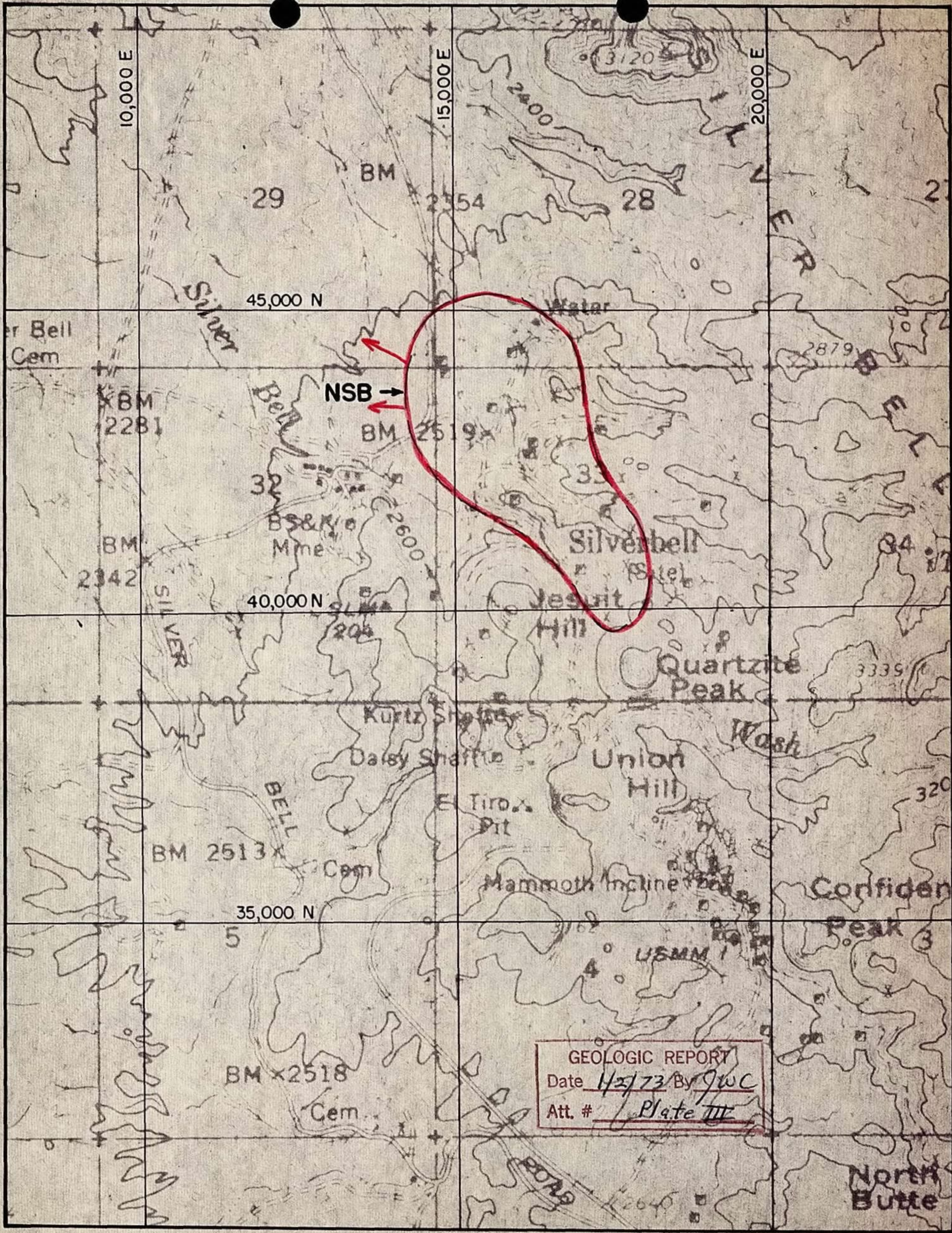
- PROPYLITIC
- ARGILLIC
- PHYLLIC
- POTASSIC

GEOLOGIC REPORT
Date 1/2/73 By JWC
Att. # Plate II

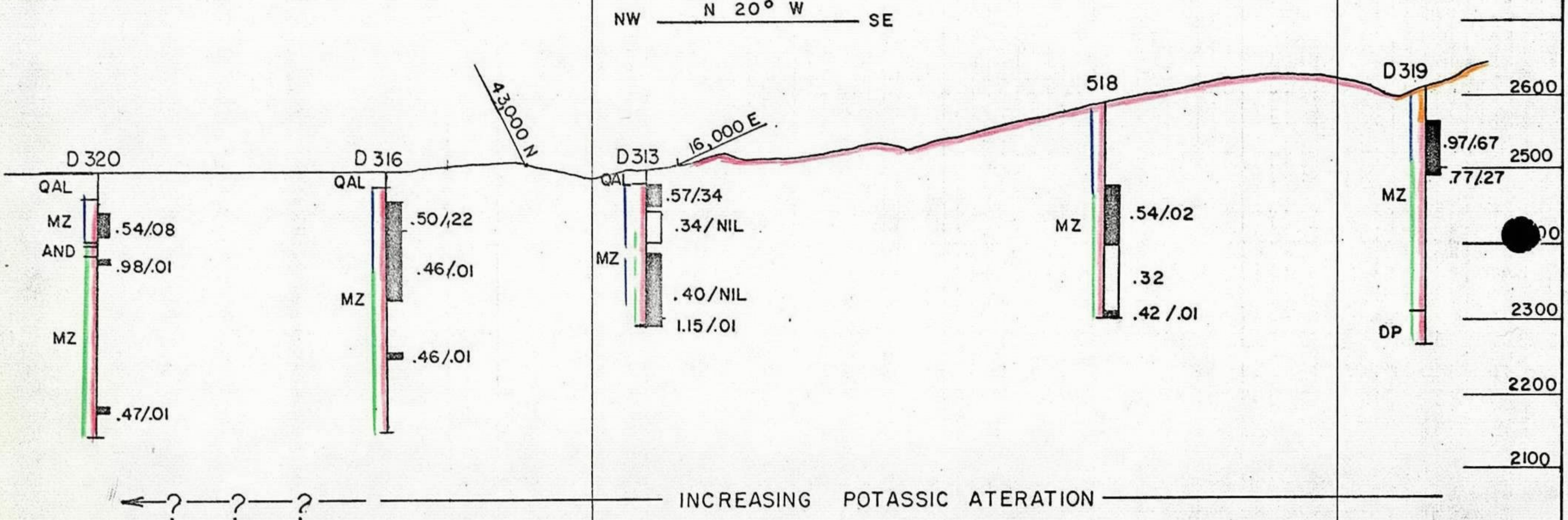
AMERICAN SMELTING AND REFINING CO.
SILVER BELL UNIT

NORTH SILVER BELL DRILL HOLE LOCATION MAP

1:12,000	JWC	8-72	S-II-II-C



SILVER BELL TOPOGRAPHY



— Chalcocite
— Chalcopyrite

Phyllic
Potassic

GEOLOGIC REPORT
Date 1/2/73 By JWC
Att. # Profile I

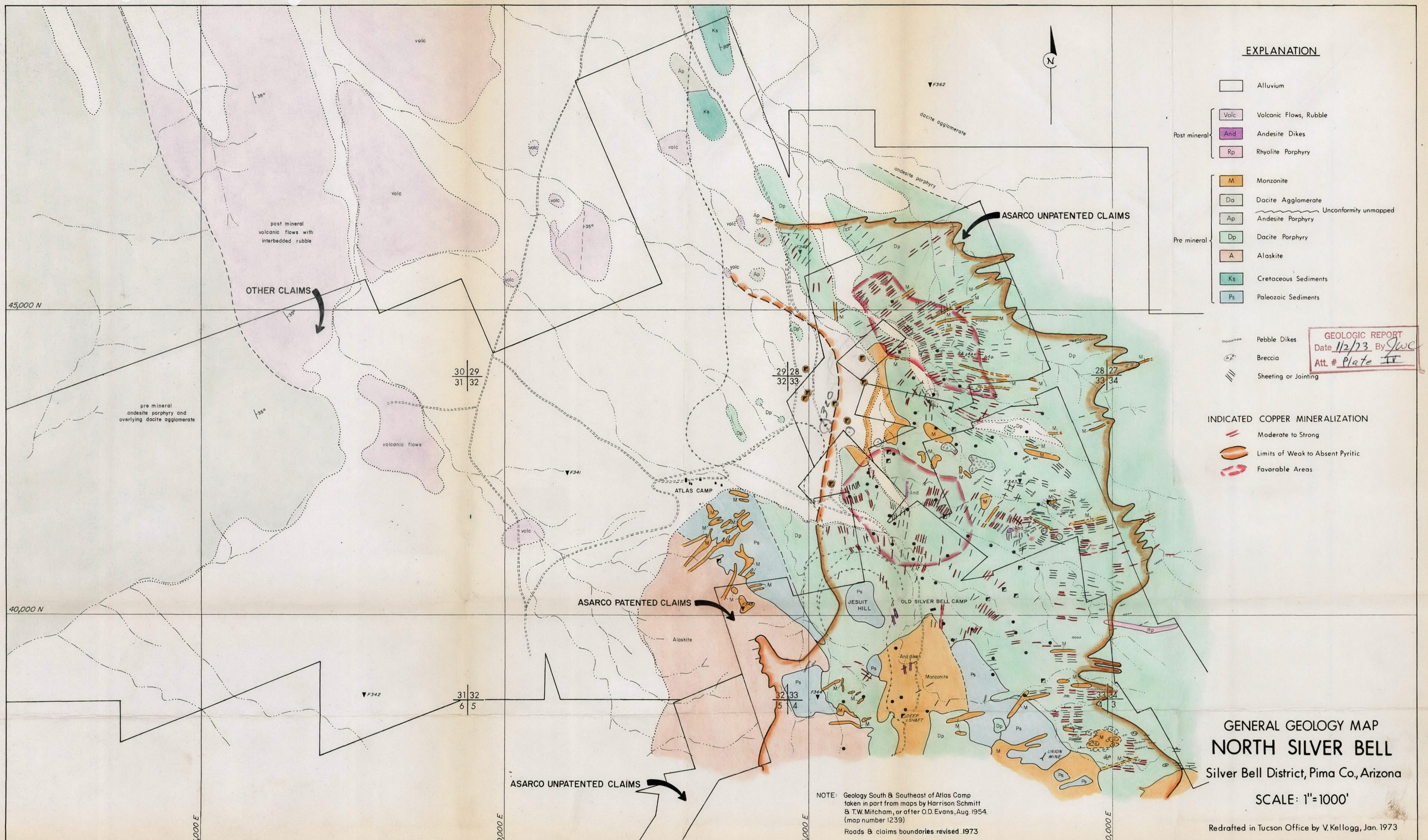
+ 0.4% Total Copper
Advance for month

Note: Rock Types Generalized
Cu Assay is Total Cu/Non Sul. Cu

AMERICAN SMELTING & REFINING CO.
SILVER BELL UNIT

NORTH SILVER BELL

SCALE	DRAWN	DATE	FILE
1" = 200'	JWC	11-72	S 121 A


EXPLANATION
Alluvium
Post mineral
Volc Volcanic Flows, Rubble
And Andesite Dikes
Rp Rhyolite Porphyry
Pre mineral
M Monzonite
Da Dacite Agglomerate
Unconformity unmapped
Ap Andesite Porphyry
Dp Dacite Porphyry
A Alaskite
Ks Cretaceous Sediments
Ps Paleozoic Sediments
Pebble Dikes
Breccia
Sheeting or Jointing
INDICATED COPPER MINERALIZATION
Moderate to Strong
Limits of Weak to Absent Pyritic
Favorable Areas
GEOLOGIC REPORT
Date 1/2/73 By JWC
Att. # Plate IV
ASARCO UNPATENTED CLAIMS
OTHER CLAIMS
ASARCO PATENTED CLAIMS
ASARCO UNPATENTED CLAIMS
post mineral volcanic flows with interbedded rubble
pre mineral andesite porphyry and overlying dacite agglomerate
volcanic flows
dacite agglomerate
andesite porphyry
ATLAS CAMP
JESUIT HILL
OLD SILVER BELL CAMP
Alaskite
Monzonite
And dikes
DEEP SHAFT
UNION MINE
45,000 N
40,000 N
5,000 E
10,000 E
15,000 E
20,000 E
F362
F341
F342
F344
NOTE: Geology South & Southeast of Atlas Camp taken in part from maps by Harrison Schmitt & T.W. Mitcham, or after O.D. Evans, Aug. 1954. (map number 1239)
Roads & claims boundaries revised 1973
GENERAL GEOLOGY MAP
NORTH SILVER BELL
Silver Bell District, Pima Co., Arizona
SCALE: 1"=1000'
Redrafted in Tucson Office by V. Kellogg, Jan. 1973

MVK 2582

J. H. C.

JUN 14 1972

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

June 13, 1972

TO: R. B. Meen
Building

FROM: W. L. Kurtz

file

Silver Bell
Copper Butte-North Butte

I am enclosing Mr. Graybeal's report which describes the results of the recent drilling by the Mining Department in subject area. The additional thirteen holes unquestionably demonstrate an ore (oxide/chalcocite) potential in this area and also have effectively defined a southern boundary.

As Mr. Graybeal points out, the indicated potential may be 2.4 million tons grading 0.74% Cu and additional drilling, especially to the north and east, will be necessary to fully define the ore zone. Several drill holes, not shown on the map, should be completed north, northwest and northeast of drill hole FR-224. The establishment of the southern limit of the ore zone should now allow planning of the maximum advance of the waste dump.

The Exploration Department will again be happy to assist when you schedule the additional drilling.

W L Kurtz
W. L. Kurtz

WLK:lad
Enc.

cc: JHCourtright - w/enc.
DRJameson - w/enc.
GWBossard - w/enc.
JJCollins - w/o enc.
FTGraybeal - w/o enc.

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

June 12, 1972

Memorandum to: W. L. Kurtz

From: F. T. Graybeal

Summary of the Copper Butte - North Butte Drilling Program, Silver Bell - Phase 2

SUMMARY AND RECOMMENDATIONS

Thirteen rotary holes were completed in the second leg of the Copper Butte drilling program. The possible ore zone has been delimited on the south and west, but is still open to the north and east. Substantial intervals of ore-grade chalcocite were intersected during the program as well as non-sulfide mineralization. The ultimate potential of the zone is estimated to be approximately 2.4 million tons at 0.74% Cu.

INTRODUCTION

Thirteen rotary holes (FR-213-225) were drilled in the Copper Butte area during the period May 22-30, 1972. The locations are shown on Plate 1 and were selected by the engineering staff at Silver Bell with the primary objective being to locate the southern limit of mineralization.

The sampling procedures were similar to those used during the initial phase of the project (see report by F. T. Graybeal, April 11, 1972). However, it was decided that retention of the entire 5 foot sample, which weighed up to 50 lbs., was unnecessary. Therefore, the sample was split at the drill site down to about 2 lbs. which was then stored in a mason jar.

RESULTS

The results of the drilling are described on the attached drill logs and are summarized in table form on Plate 1. The absence of significant mineralization in FR-213, 214, 215, 216, 219, and 220 define the southern limit of potential ore-bearing rock and should enable the maximum advance of the waste dumps to be surveyed.

Hole FR-221 cut 95 feet of 0.42/0.37% Cu and probably defines the western limit of the potential ore zone. Hole F-150 which lies 135 feet west of FR-221 contained a significant interval of non-sulfide copper mostly in a

2 foot thick andesite dike. I do not believe this hole represents a significant volume of mineralized rock and it is therefore considered to be outside what now appears to be the ore zone.

Significant intervals of high grade mineralization were cut by FR-217, 218, 222, 223, and 224. Unfortunately FR-217, 218, and 223 were bottomed in ore due to drilling difficulties or insufficient rods. All holes are located within the northwest-striking zone of post-mineral (hypogene) andesite dikes which emphasizes that these dikes exerted an important control on the movement of cupriferous ground water and were themselves reactive zones within which copper was deposited. Holes 217, 218, 222, and 223 contain large amounts of chalcocite in addition to non-sulfide minerals.

Although the south and west sides of the potential ore zone appear well established, the north and east sides remain open to expansion. Hole FR-224 cut 35 feet of 1.15/1.14% Cu starting 8 feet below the bedrock surface. This hole, which lies within the northward projection of the andesite dike system, demonstrates the potential for additional non-sulfide mineralization in the concealed bedrock in this area. Abundant mineralization is also present in outcrops 200 feet north and 300 feet southwest. In addition, hole F-152, which lies along strike of the mineralization in these outcrops contains 36.4 feet of 0.38% Cu as chalcocite starting at 79.5 feet. These occurrences illustrate the possibility of expanding the potential ore zone to the north, particularly where the northeast (apparently)-striking zone of copper oxide mineralization intersects the andesite dikes.

Expansion of the potential ore zone to the east is a certainty although the amount is difficult to estimate. Hole F-151, which is barren, lies roughly 300 feet east of the present drilling, and it is reasonable to assume that 100 feet of this width will contain +0.40% Cu mineralization. Figure 1 demonstrates that non-sulfide mineralization gives way to the east to sulfide mineralization, mostly as chalcocite. Thus, the potential in the area east of the present drilling appears to be primarily as sulfide at depths greater than previously encountered for the non-sulfides.

DISCUSSION

The non-sulfide mineralization is present as chrysocolla, malachite, tenorite, cuprite, and native copper and is most abundant in and along the contacts of the andesite dikes. The extent of this mineralization into the adjacent wall rocks is not presently known; however, if further drilling justifies an ore reserve calculation it would be advisable to drill a shallow angle hole or several close-spaced vertical holes across the dike-wall rock contact in order to determine the necessity of geologically adjusting the polygons. To date, ore grade non-sulfides have been encountered at depths varying from the surface to in excess of 110 feet.

Sulfide copper mineralization was established by the present drilling to be an important component of the overall zone. It occurs mostly as chalcocite at depths from 10 feet to in excess of 150 feet. Movement of water through these near-surface occurrences of chalcocite is undoubtedly responsible for the formation of the peculiar, sulfate-looking, green crusts which have developed along many of the joints. This type of copper oxide occurrence is particularly well developed in the western copper oxide zone and must now be reinterpreted as indicating near-surface chalcocite rather than pervasive oxide mineralization.

Limonite after chalcocite is also absent in outcrops over the high grade chalcocite encountered in the present drilling. This fact, in addition to the presence of altered rocks higher on the hill, attest to the almost certain lateral migration of copper-bearing groundwater downslope along the northeast-striking altered veins. I am certain that additional drilling will prove that the areas of highest grade chalcocite will weaken east of the andesite dikes, even though rocks become progressively more altered in this direction. This illustrates that the location of the andesite dikes in a topographic low, which coincides almost exactly with the irregular southwest limit of hydrothermal alteration, has been perhaps the most important ore control in the area. It also proves that the major cycle of oxidation and enrichment in the Copper Butte-North Butte area occurred after emplacement of the andesite dikes, and thus after the Mid-Tertiary volcanic epoch in southern Arizona.

The concept of lateral-moving, copper-bearing groundwater may have interesting implications for areas such as the Battery Incline, the southwest side of Wild Hog Butte, and the west side of Mt. Expectation. Although ore-grade zones in these areas are probably too small to mine, they might eventually be amenable to _in situ_ leaching.

POTENTIAL OF THE COPPER BUTTE AREA

A rough ore potential was calculated for the Copper Butte area as shown on Figure 1. For the two blocks shown, all assays, regardless of grades, to depths of 100 and 120 feet respectively were averaged together and indicate 2.4 million tons averaging 0.74/0.45% Cu. This figure includes substantial intervals of waste which could be excluded by mining from 20 foot benches, and thus, the tonnage is probably too high and the grade too low. Nevertheless, the figures do indicate the potential of the Copper Butte area.

RECOMMENDATIONS

Sixteen additional holes are proposed to evaluate further the Copper Butte area. The locations of these holes are shown on Plate 1.

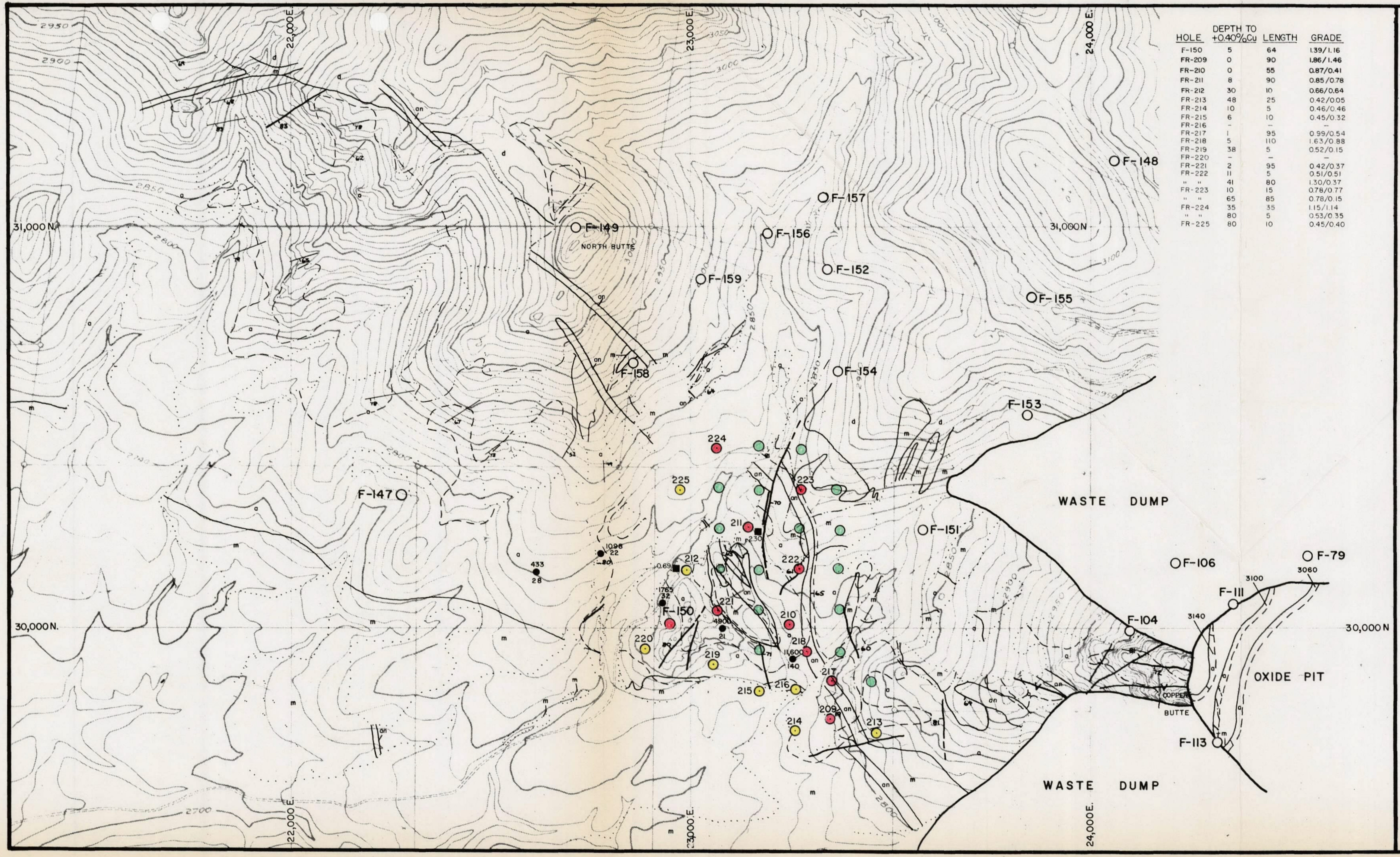
The projected depths would be in the 100-150 foot range, particularly for holes east of the present drilling. The increase over previous estimated depths is due to the probable occurrence of chalcocite which extends to greater depths than the non-sulfide mineralization. Also, arrangements should be made to add additional rods to the tower of the CP-385 as drilling below 150 feet may be necessary. If this program is successful, drilling of the non-sulfide area northwest of F-147 will also have to be considered.

F. T. Graybeal

F. T. Graybeal

FTG;sg
attachs.

PLATE 1



HOLE	DEPTH TO +0.40% Cu	LENGTH	GRADE
F-150	5	64	1.39/1.16
FR-209	0	90	1.86/1.46
FR-210	0	55	0.87/0.41
FR-211	8	90	0.85/0.78
FR-212	30	10	0.66/0.64
FR-213	48	25	0.42/0.05
FR-214	10	5	0.46/0.46
FR-215	6	10	0.45/0.32
FR-216	–	–	–
FR-217	1	95	0.99/0.54
FR-218	5	110	1.63/0.88
FR-219	38	5	0.52/0.15
FR-220	–	–	–
FR-221	2	95	0.42/0.37
FR-222	11	5	0.51/0.51
" "	41	80	1.30/0.37
FR-223	10	15	0.78/0.77
" "	65	85	0.78/0.15
FR-224	35	35	1.15/1.14
" "	80	5	0.53/0.35
FR-225	80	10	0.45/0.40

LEGEND

- an — andesite
- m — monzonite
- d — dacite
- a — alaskite
- faults (60°)
- areas of pervasive hydrothermal alteration
- veins: quartz, quartz–sericite — shown only outside of areas of hydrothermal alteration

Areas of copper oxide mineralization

- 0.1–0.5 % Cu in outcrop (estimated)
- + 0.5 % Cu in outcrop (estimated)
- rock chip samples showing total $\frac{Cu}{Mo}$ ppm (1098 / 22)
- assay showing total Cu in % (0.69)
- proposed drill holes
- completed drill holes (FR series) (209)
- > 40 ft @ + 0.40 % Cu.
- < 40 ft @ + 0.40 % Cu.

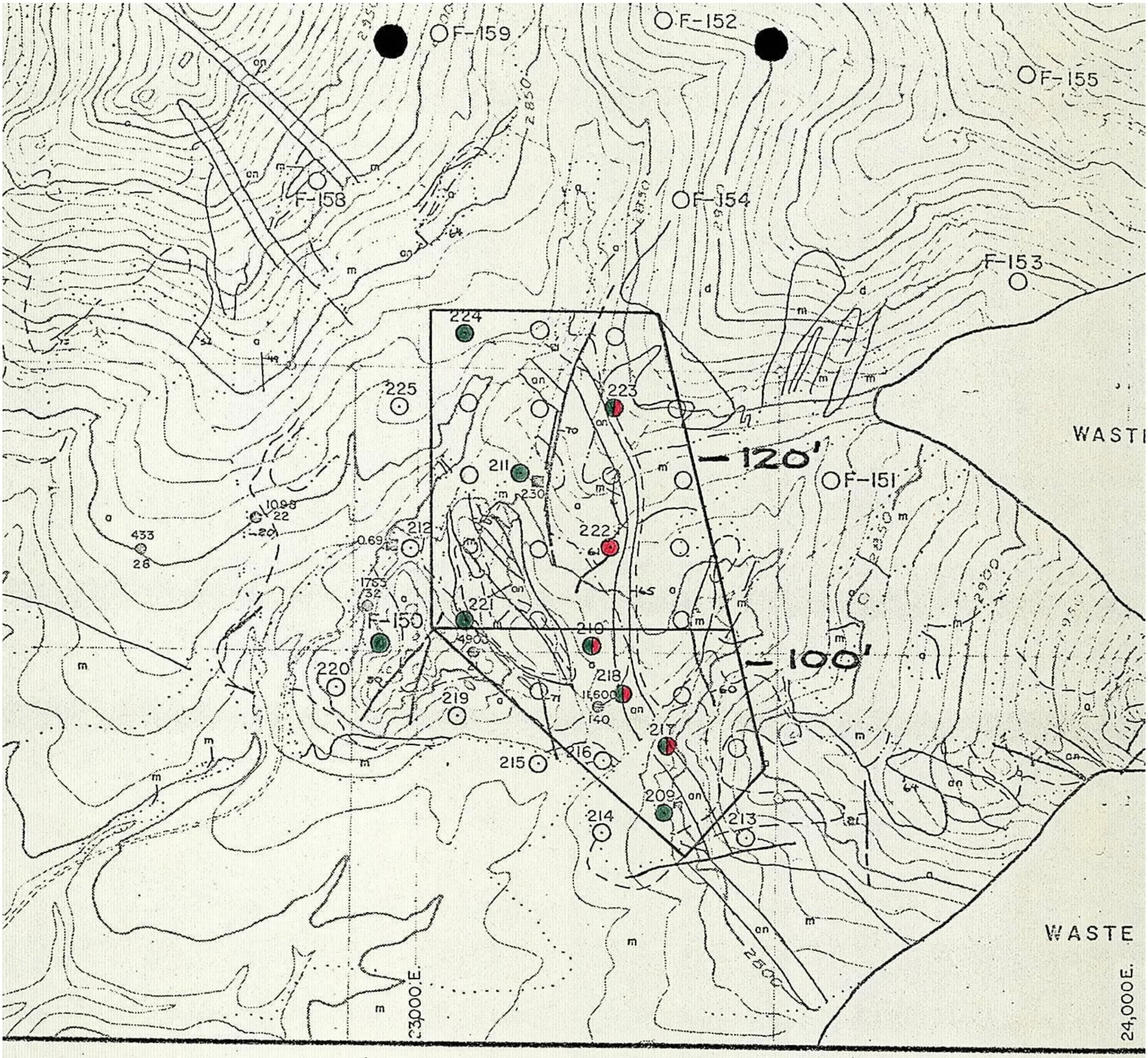
GEOLOGIC MAP
COPPER BUTTE–NORTH BUTTE AREA
SILVER BELL UNIT
ARIZONA

1" = 200'

March 1972
Revised, June 1972

F.T.G.

mn 2537 DAM



sulfide ore -- +40' @ +0.40% Cu

non-sulfide ore -- +40' @ +0.40% Cu

Figure 1. Area used for calculation of ore potential near Copper Butte, Silver Bell.

Final Depth 93'
Collar Elevation 2820.58
Coordinates 29738.44 N, 23465.69 E
Inclination vertical

ASARCO

GEOLOGIC – ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-213
Sheet No. 1
Date Completed 5/22/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration	Rock Type	Remarks
- 3	3	6"													alluvium
8	5	rotary			.21	.20								alaskite	fresh; tr lim, blk oxide
13	5				.24	.23								alaskite/monzonite	as above
18	5				.14	.14									" "
23	5				.14	.12									" " w. tr py
28	5				.18	.16								alaskite	as above
33	5				.23	.11									fresh; tr cc-py-cpy
38	5				.26	.12								mixed alaskite/monzonite	as above
43	5				.35	.11									" "
48	5				.21	.07									" "
53	5				.49	.09									wk chlor alt; tr lim, sp cc-py-cpy
58	5				.36	.05	25'								as above
63	5				.27	.04	@								as above w. increased pink kspar
68	5				.44	.06	0.42/.05								as above
73	5				.55	.03									" "
78	5				.20	.01								alaskite	" "
83	5				.22	.02									" "
88	5				.25	.01									" "
93	5				.21	.01									" "

Final Depth 74'
Collar Elevation 2782.75
Coordinates 29743.88 N, 23260.77 E
Inclination vertical

ASARCO
GEOLOGIC-ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-214
Sheet No. 1
Date Completed 5/22/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration		Rock Type	Remarks
-5	5	6"			.10	.09									monzonite	st. chlor alt of bio.; 10% pink kspar; tr blk oxide
10	5	rotary			.19	.17										as above
15	5				.46	.46										as above with tr mal, st. blk oxides
20	5				.10	.10										as above with no mal.
25	5				.13	.11										as above
30	5				.09	.09										" "
35	5				.13	.12										as above w. sp blk oxides
40	5				.07	.07										as above
45	5				.07	.06										" "
50	5				.06	.06										" "
55	5				.09	.09										" "
60	5				.08	.07										" "
65	5				.07	.06										as above with tr py-cc
70	5				.05	.05										as above
74	4				.03	.03										" "

Final Depth 76'
Collar Elevation 2770.12
Coordinates 29841.92 N, 23172.03 E
Inclination vertical

ASARCO
GEOLOGIC - ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-215
Sheet No. 1
Date Completed 5/23/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration		Rock Type	Remarks
0 - 1	1	6"														alluvium
6	5	rotary			.32	.31									monzonite	leached; mod chlor alt of bio; mod lim, sp chry-blk ox.
11	5				.50	.36	10' @ .45/.32									as above with no chry
16	5				.40	.29										as above
21	5				.12	.09										" "
26	5				.07	.06										" "
31	5				.07	.05										" "
36	5				.05	.04										as above with tr py
41	5				.07	.05										as above
46	5				.06	.04										" "
51	5				.08	.05										" "
56	5				.04	.02										mod chlor-ser; sp lim; sp py
61	5				.03	.02										as above
66	5				.05	.04										" "
71	5				.05	.02										" "
76	5				.04	.02										" "

Final Depth 73'
Collar Elevation 2773.99
Coordinates 29847.11 N, 23263.60 E
Inclination vertical

ASARCO
GEOLOGIC – ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-216
Sheet No. 1
Date Completed 5/23/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration		Rock Type	Remarks
0-3	3	6"														alluvium
8	5	rotary			.31	.30									monzonite	leached; mod chlor alt of bio; mod blk ox, sp mal
13	5				.14	.14										as above w. no mal.
18	5				.11	.11										as above
23	5				.12	.11										" "
28	5				.14	.10										" "
33	5				.09	.03										" "
38	5				.20	.07										" "
43	5				.10	.02										as above w. tr Cu°
48	5				.21	.04									alaskite	wk alt ?; tr f.g. py; tr Cu° (very fine cuttings)
53	5				.16	.02										as above w. tr cc
58	5				.18	.02										as above
63	5				.19	.01										" "
68	5				.16	.02										" "
73	5				.12	.01										" "

Final Depth 98'
Collar Elevation 2791.07
Coordinates 29868.05 N, 23354.30 E
Inclination vertical

ASARCO
GEOLOGIC – ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-217
Sheet No. 1
Date Completed 5/23/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu: Total	Non-S	Average	Mineralization: Oxides	Pyrite	Cpy	Cc	Other	Alteration	Rock Type	Remarks
0-1	1	6"													alluvium
6	5	rotary			2.48	2.35								andesite	dk gy; mod chry-mal, sp azur-blk ox
11	5				2.25	2.14									as above w. sp cup
16	5				1.66	1.59									as above w. tr Cu°
21	5				.69	.44								17' alaskite	as above to 17', then wk clay alt; sp chry-blk ox-cc
26	5				.49	.27									sp clay-ser alt; sp cc-py, sp mal-lim-blk ox-cup
31	5				.50	.18									as above
36	5				.73	.26									as above w. mod cc-py, tr copper oxides
41	5				.81	.18	95'								as above
46	5				.77	.19	@								wk clay-ser alt., mod cc-py, tr lim
51	5				.68	.21	0.99								as above w. tr moly-cpy
56	5				.60	.14	0.54								as above
61	5				.56	.10									as above w. tr cup-Cu°
66	5				.81	.11									mod clay-ser-chlor, tr lim, sp cc-py, tr moly-cpy
71	5				.67	.10									as above
76	5				.66	.20									" "
81	5				.93	.17									mod chlor-ser; mod cc-py, tr cpy
86	5				1.21	.39								andesite	mod Cu° on fractures
91	5				1.33	.84									as above w. tr cup-chry
96	5				1.04	.50								93' alaskite	as above to 93', then mod chlor-ser; sp cc-py
98	2				no	sample									probably as above, only minor recovery

hole abandoned at 98' after entering old working

Final Depth 115'
Collar Elevation 2787.53
Coordinates 29941.73 N, 23291.86 E
Inclination vertical

ASARCO

GEOLOGIC - ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-218
Sheet No. 1
Date Completed 5/22/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration		Rock Type	Remarks
0-5	5	6"														alluvium
10	5	rotary			.85	.66									alaskite	leached; mod silicif; mod chry, sp blk ox
15	5				.79	.42										mod silicif; sp dissem cc-py-cpy, sp chry-blk ox
20	5				1.42	.71										as above w. sp mal.
25	5				.96	.30										as above
30	5				.78	.21										" "
35	5				.66	.19										" "
40	5				.79	.42										as above, copper mostly as chry
45	5				.57	.24										as above
50	5				.86	.47										" "
55	5				.68	.20	110'									wk silicif; sp dissem cc-py-cpy-moly, tr chry-lim-cup
60	5				.64	.11	@									as above
65	5				1.40	.43	1.63									" "
70	5				3.35	2.42	0.88									wk silicif-chlor; sp py-cc-moly, st brn lim, mod cup-Cu°
75	5				2.00	1.00										as above
80	5				1.61	.58										" "
85	5				1.86	.62										" "
90	5				2.14	.99										as above w. no Cu°
95	5				1.99	1.10										as above
100	5				2.54	2.08									andesite	mod lim-cup, tr olive-green ads. Cu ?
105	5				5.42	2.95										mod cup-lim, sp Cu° (Cu° coats joints)
110	5				2.72	1.82										mod Cu°-lim, sp cup
115	5				2.01	1.52										mod Cu° - cup, sp lim

at 115.5' hit very heavy water flow, hole abandoned

Final Depth 83'
Collar Elevation 2782.87
Coordinates 29909.49 N, 23056.44 E
Inclination vertical

ASARCO
GEOLOGIC – ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-219
Sheet No. 1
Date Completed 5/24/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration		Rock Type	Remarks
0-3	3	6"														alluvium
8	5	rotary			.27	.26									alaskite	wk clay-ser; sp lim-blk ox-ads Cu
13	5				.17	.16										as above
18	5				.15	.14										" "
23	5				.18	.14										" "
28	5				.20	.17										wk chlor-ser; sp lim-blk ox
33	5				.17	.14										as above
38	5				.10	.08										" "
43	5				.52	.15										wk chlor-ser; sp cc-py, tr lim-blk ox
48	5				.13	.10										as above
53	5				.10	.09										" "
58	5				.17	.14										" "
63	5				.11	.08										" "
68	5				.14	.13										" "
73	5				.18	.05										" "
78	5				.16	.05										" "
83	5				.14	.04										" "

Final Depth 111'
Collar Elevation 2805.49
Coordinates 29948.09 N, 22884.22 E
Inclination vertical

ASARCO
GEOLOGIC - ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-220
Sheet No. 1
Date Completed 5/24/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu			Mineralization					Alteration	Rock Type	Remarks
					Total	Non-S	Average	Oxides	Pyrite	Cpy	Cc	Other			
0 - 1	1	6"													alluvium
6	5	rotary			.12	.11								alaskite	wk clay alt; sp brn lim - ads Cu
11	5				.11	.10									as above w. sp blk ox.
16	5				.09	.08								19'	as above w tr mal
21	5				.10	.08								monzonite 25'	as above to 19', then wk chlor, sp lim - blk ox
26	5				.12	.11								alaskite	as above
31	5				.12	.09									wk clay alt; sp lim - blk ox.
36	5				.09	.08									as above
41	5				.09	.08									as above w. tr mal
46	5				.13	.13									as above w. sp lim - blk ox - mal
51	5				.16	.15									as above
56	5				.20	.19									" "
61	5				.13	.13									" "
66	5				.13	.13									" "
71	5				.29	.29									as above w. tr mal, mod blk oxide
76	5				.10	.09									as above w. tr mal, sp blk ox.
81	5				.06	.06									as above
86	5				.08	.06									as above w. sp mal - chry - blk ox
91	5				.20	.11									sp bio - chlor - clay; sp mal - blk ox
96	5				.14	.09									as above w. tr py, tr chry
101	5				.35	.07									sp chlor - clay; tr cc - py, tr lim - mal
106	5				.17	.05									as above
111	5				.15	.03									" "

Final Depth 112'
Collar Elevation 2816.36
Coordinates 30042.65 N, 23068.01 E.
Inclination vertical

ASARCO
GEOLOGIC - ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-221
Sheet No. 1
Date Completed 5/24/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu: Total	Non-S	Average	Mineralization: Oxides	Pyrite	Cpy	Cc	Other	Alteration		Rock Type	Remarks
0-2	2	6"														alluvium
7	5	rotary			.48	.47									alaskite	fresh; sp brn lim, mod ads Cu
12	5				.17	.17										as above mixed with clasts of st ser - maroon lim
17	5				.35	.35										fresh; sp brn lim, mod adsorbed Cu
22	5				.67	.67										as above; tr monz.
27	5				.66	.66									monzonite	sp chlor-clay alt; sp lim-ads Cu
32	5				.29	.29										mod chlor-clay alt; mod lim, tr ads Cu
37	5				.30	.30										as above mixed w. clasts of st. ser (altered veins?)
42	5				.30	.30										as above
47	5				.33	.32	95'									as above w. tr cc-py, tr mal
52	5				.43	.43	@									as above
57	5				.33	.24	0.42									as above; st lim clasts mixed w. sul. clasts (no lim)
62	5				.45	.19	0.37									as above
67	5				.38	.24										as above w. mod cc-py
72	5				.39	.38									alaskite	leached; sp clay; mod lim, sp ads. Cu
77	5				.34	.33										as above w. sp mal
82	5				.57	.57										mod clay-ser; mod lim, sp chry-mal
87	5				.47	.39										as above w. tr cc-py
92	5				.74	.56										as above w. sp cc-py, mod mal
97	5				.50	.21									monzonite	mod chlor-ser; mod cc-py, tr mal, no lim
102	5				.31	.08										as above
107	5				.16	.04										as above w. sp cc-py
112	5				.12	.02										as above

Final Depth 131'
Collar Elevation 2819.51
Coordinates 30148.81 N, 23271.81 E
Inclination vertical

ASARCO
GEOLOGIC – ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-222
Sheet No. 1
Date Completed 5/24/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu			Mineralization					Alteration		Rock Type	Remarks
					Total	Non-S	Average	Oxides	Pyrite	Cpy	Cc	Other				
0-1	1	6"														alluvium
6	5	rotary			.22	.19									alaskite	mixed fresh, splim-chry and st ser alt.
11	5				.36	.34										as above w. mod chry-ads Cu, sp blk ox.
16	5				.51	.51 }										as above
21	5				.09	.07										leached; mod ser alt, mod maroon lim, no CuOx
26	5				.06	.04										as above
31	5				.05	.03										" "
36	5				.11	.07										as above w. Tr cc-py
41	5				.20	.11										as above w. sp ads Cu
46	5				1.29	.23	↑									as above
51	5				.75	.22										mod ser alt, tr lim, sp cc-py
56	5				1.09	.27										as above w. st. replacement of py by cc.
61	5				1.84	.37										" "
66	5				1.92	.28										" "
71	5				1.75	.34	80'									" "
76	5				2.96	.63	@									" "
81	5				.82	.16	1.30/									" "
86	5				.64	.13	0.37									" "
91	5				.50	.11										" "
96	5				.95	.14										" "
101	5				.69	.27										" "
106	5				2.21	.62									110'-	mod ser alt, 5-10% pyrite w. mod cc
111	5				1.24	.32									monzonite	as above to 110', then mod chlor-ser, mod cc [illegible] tr Cu
116	5				1.70	1.52									117'-	as above
121	5				.57	.31	↓								andesite	as above to 117, then mod cup, sp lim-mal-Cu
126	5				.23	.14										sp cup- Cu
131	5				.07	.05										as above

Final Depth 150'
Collar Elevation 2852.64
Coordinates 30346.57 N, 23277.72 E
Inclination vertical

ASARCO
GEOLOGIC - ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-223
Sheet No. 1
Date Completed 5/30/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration		Rock Type	Remarks
0-5	5	6"			.12	.12									alaskite	leached; mod clay-ser alt; mod lim, tr ads Cu
10	5	rotary			.36	.35									7' andesite	as above to 7', then sp lim- chry- blk ox
15	5				.83	.83	15'									as above
20	5				.86	.85	@									as above w. tr mal, tr ads Cu on plag.
25	5				.66	.65	0.78/0.77									as above
30	5				.33	.33										" "
35	5				.18	.18										" "
40	5				.11	.11									36' alaskite	as above to 36', then leached; mod ser alt, mod brn lim
45	5				.12	.12										as above w. mixed wk clay sections, sp ads Cu
50	5				.06	.06										as above
55	5				.06	.06										as above w. tr cc-py
60	5				.05	.05										as above
65	5				.04	.04										" "
70	5				1.78	.13										" "
75	5				.39	.09										as above to 72, then sulfide zone; st ser, mod cc-py
80	5				.38	.09										as above, estimate 5% py
85	5				.88	.12										as above
90	5				.55	.13										" "
95	5				.64	.13										" "
100	5				.46	.09	85'									" "
105	5				.63	.10	@									st. qtz-ser alt, mod cc-py-cpy-moly
110	5				1.50	.18	0.78/0.15									as above
115	5				1.47	.26										as above w. mod pink kspar
120	5				.99	.22										as above
125	5				.97	.25										as above w tr monzonite ?
130	5				.57	.17										st ser, mod pink kspar, mod cc-py
135	5				.48	.19										as above
140	5				.46	.16										" "
145	5				.58	.15										" "
150	5				.57	.10										" "
		insufficient drill rods to continue the hole														

Final Depth 120
Collar Elevation 2828.62
Coordinates 30449.26 N, 23064.50 E
Inclination vertical

ASARCO
GEOLOGIC – ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-224
Sheet No. 1
Date Completed 5/30/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration		Rock Type	Remarks
0-5	5	6"			.07	.06									Gila cg	
10	5	rotary			.06	.05										
15	5				–	–										
20	5				.06	.05										
25	5				.08	.07									27'	
30	5				.28	.27									alaskite	wk clay alt; mod chry - ads Cu
35	5				.33	.32										as above w. sp blk ox - mal
40	5				.40	.39										as above w. tr py
45	5				1.35	1.35										wk clay alt; mod chry-mal-blk ox, tr azur
50	5				3.10	3.00	35'								andesite	tr lim, mod-st mal-blk ox, tr azur-chry
55	5				1.25	1.25	@									as above
60	5				.83	.82	~~1.15~~									" "
65	5				.69	.69	1.14									st azurite - glassy chry, mod mal - blk ox, tr lim
70	5				.49	.49										mod azur - chry - blk ox, sp mal - lim
75	5				.30	.30										mod azur - pale grn. chry, sp lim - blk ox
80	5				.19	.19										as above w. tr monzonite
85	5				.53	.35 }										as above w. tr monz. and tr cc-py
90	5				.30	.19									monzonite	mixed leach + sul; mod clay-chlor alt; sp cc-py-CuOx
95	5				.27	.20										as above
100	5				.34	.13										sp ser alt; sp cc-py, tr lim
105	5				.32	.11										as above w. sp pink kspar
110	5				.21	.05										as above
115	5				.22	.04										" "
120	5				.12	.03										" "

Final Depth 100'
Collar Elevation 2818.46
Coordinates 30343.42 N, 22971.62 E
Inclination vertical

ASARCO
GEOLOGIC – ASSAY LOG

Property Copper Butte, Silver Bell

HOLE NO. FR-225
Sheet No. 1
Date Completed 5/30/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu: Total	Non-S	Average	Mineralization: Oxides	Pyrite	Cpy	Cc	Other	Alteration		Rock Type	Remarks
0-5	5	6"			.06	.05									Gila cmg	
10	5	rotary			.06	.05										
15	5				.07	.06										
20	5				.06	.06										
25	5				.07	.07										
30	5				.10	.09									29' – monzonite	leached, mixed st ser and fresh, sp chry
35	5				.17	.17										as above w. no CuOx
40	5				.15	.13										as above w. st. lim.
45	5				.14	.14										as above
50	5				.16	.14										" "
55	5				.20	.19										" "
60	5				.17	.14										" "
65	5				.25	.25										" "
70	5				.31	.30										" "
75	5				.23	.21										" "
80	5				.31	.30										" "
85	5				.50	.49	10' @									" "
90	5				.40	.30	0.45 / 0.40									as above to 89', Then sp clay-ser alt, Tr py-cc
95	5				.30	.23										as above w. mixed leached clasts
100	5				.31	.26										as above

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

J. H. C.
MAY 2 - 1972

April 27, 1972

TO: R. B. Meen
Building

FROM: W. L. Kurtz

Copper Butte Drilling
Silver Bell ← file

Enclosed is Fred Graybeal's report on the drilling program at Copper Butte. As Mr. Graybeal points out, the results of the four rotary drill holes are very encouraging and, therefore, it is imperative that no waste dumps be put over the Copper Butte area.

Additional drilling will be necessary to determine whether an oxide copper reserve exists. The potential of two million tons of .8 oxide copper certainly justifies the 24 drill holes with an average depth of 100 feet recommended by Mr. Graybeal. As pointed out by Mr. Graybeal, the Silver Bell Unit's drill makes an excellent drill for the exploration work at Copper Butte.

We would be happy once again to assist in the drilling of the proposed holes.

W. L. Kurtz
W. L. Kurtz

WLK:lad
Enc.

cc: DRJameson - w/enc.
RSHerde - w/o enc.
RABarnes "
JWCameron "
FTGraybeal "
JJCollins "
JHCourtright - w/enc.

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

April 11, 1972

Memorandum to: W. L. Kurtz

From: F. T. Graybeal

Summary of the Copper Butte-North Butte Drilling Program, Silver Bell

SUMMARY AND RECOMMENDATIONS

Four rotary holes were recently drilled just west of Copper Butte to test an area of copper oxide mineralization. Three of these encountered intervals of 55 feet or more of +0.80% Cu as shown on the attached map. The results demonstrate the copper oxide ore potential and indicate a need for additional drilling before the area can be used for dumping waste from Oxide pit. Twenty-four holes averaging 100 feet in depth are proposed to complete this test.

INTRODUCTION

Four rotary holes were drilled in the Copper Butte area just west of Oxide pit on March 21-22, 1972. The locations are shown on the attached map. Scheduling of the drill, site preparation, and provision of sample collection materials were arranged by R. A. Barnes and J. W. Cameron of the Silver Bell Unit.

DRILLING AND SAMPLING PROCEDURES

Drilling was performed with a truck mounted Chicago-Pneumatic 385 which is based at the Silver Bell Unit. This machine drills a 6 inch rotary hole using air circulation and has a depth capability of about 200 feet with the present compressor. The rate of advance averaged about one foot per minute, sufficiently rapid to require the services of a sampler in addition to the driller and helper.

Samples were collected in two triangular-shaped wooden boxes with an opening at one apex. These boxes were placed with the open end against the drill stem so as to catch cuttings as they were blown out of the hole. Sampling by this procedure on 5 foot intervals yielded about 30 lbs. of rock cuttings all less than 1/4 inch size. Recovery was generally less for the first 5-10 feet due to cuttings being blown out into the well-fractured surface portions of the hole. The samples were stored in one cubic foot cardboard boxes.

Logging of the cuttings, after washing, indicated that contamination of deeper samples with material abraided from upper portions of the hole was negligible. All samples were assayed at the Silver Bell Unit.

RESULTS

The results of the drilling are tabulated on the attached drill logs and summarized in table form on the accompanying map. Hole FR-109 cut 90 feet of 1.86/1.46% Cu starting at the surface. The particularly high grade section from 60 to 80 feet resulted from the hole passing along the contact of an andesite dike without entering the dike for more than 5 continuous feet. This was unexpected as surface dips indicated the hole should have entered the dike at about 100 feet; and may have upgraded the hole with respect to adjacent rocks farther from the dike.

Hole FR-210 cut 55 feet of 0.87/0.41% Cu starting at the surface, all in alaskite and monzonite. A surprisingly large amount of copper occurred as chalcocite which was first encountered at a depth of 10 feet.

Hole FR-211 cut 90 feet of 0.85/0.78% Cu starting at the bedrock surface. This hole entered an andesite dike which was not present at the surface, and which carried higher than average values.

Hole FR-212 cut 10 feet of 0.66/0.64% Cu starting at 30 feet. This section is not of sufficient grade to carry a 40 foot bench at 0.40% Cu due to the overall low grade of the remaining intervals. These results were unexpected as copper oxide minerals are abundant in all surface outcrops adjacent to the collar of this hole.

DISCUSSION

The relationship of rock type to the distribution and grade of copper was estimated from holes F-150 and FR-209-212 and is shown in Table 1.

TABLE 1: Distribution of copper and volume of rock types encountered in Copper Butte Area.[1.)]

Rock Type	Volume %	% Intervals at +0.40% Cu	average grade to depth of 90 feet
andesite	16	100	2.21% Cu
alaskite	38	75	0.72% Cu
monzonite porphyry	46	40	0.66% Cu

1.) using F-150 and FR-209, 210, 211, 212.

The lower grade and abundance of ore intervals in the monzonite result from its unreactive composition, weaker shattering, and occurrence mostly at depth. All five holes bottomed in monzonite, suggesting that the potential for ore grade non-sulfide mineralization below 100 feet is nil.

The potential tonnage inferred by the present drilling is very roughly 2 million tons to a depth of 90 feet. The average of all holes to this depth, regardless of grade, is 0.92% Cu. The grade may be too high, particularly as the high assays in F-150 are primarily confined to a 2 foot andesite dike.

Intersections of post-mineral andesite clearly raise the average grade of the copper oxide-bearing area, and Table 1 shows that 16 percent of the drilling was in andesite dike. Thus the amount of andesite in this area is substantial, and the ability of the andesite to carry lower grade zones of alaskite and monzonite will be an important factor in determining whether or not the area will ultimately be mineable. Clearly the andesites should not be intentionally avoided during future drilling.

The presence of higher grade values in FR-209, 210, and 211 suggest that the parallel zone of andesite dikes, in which these three holes occur (see Plate 1, report to W. L. Kurtz dated March 20, 1972), may contain better overall grades than rocks to the northeast and southwest. Therefore, particular attention should be given to the covered area between FR-211 and F-158, where significant copper oxide mineralization may be concealed.

RECOMMENDATIONS

The potential of the central copper oxide area has been demonstrated by the recent drilling program. The results establish that this area should not be used as a waste dump until further drilling has been completed. The somewhat unpredictable distribution of andesite dikes indicates that additional drilling in the area should be performed on a 100 foot grid. Twenty-four holes to average 100 feet in depth are proposed to evaluate more completely the central copper oxide area as shown on the attached map.

F. T. Graybeal

F. T. Graybeal

FTG:sg
attach.

Final Depth 125'
Collar Elevation
Coordinates
Inclination vertical

ASARCO
GEOLOGIC – ASSAY LOG

Property Copper Butte - Silver Bell

HOLE NO FR-209
Sheet No. 1
Date Completed 3/21/72
Logged By FTG

Depth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration Clay-ser	Kspar	Rock Type	Remarks
5	5	6"			.51	.51									alaskite	brkn, leached
10	5	rotary			.85	.85										fresh, mod chry - ten
15	5				1.52	1.46										as above
20	5				.74	.44										" "
25	5				.68	.25										fresh, leached, weak chry - ten.
30	5				.81	.53										fresh, mixed wk. lim w. chry and tr py-cc-cpy
35	5				.72	.57										as above
40	5				1.45	.82	90'									" "
45	5				1.38	.66	@									" "
50	5				.93	.51	1.86/						wk		48' - monz.	" "; monz. wk clay-ser (greenish), tr py blk oxide
55	5				2.13	.60	/1.46									monz. as above
60	5				2.30	1.54							mod			st. shattering, mod clay-ser, strong chry-cup-mal
65	5				6.39	5.96										mixed monz. - andesite dike, st. azur, tr cup-chry-mal
70	5				3.50	3.40										monz. only, mod. clay-ser, st. azur, tr chry - cup.
75	5				4.08	3.82									70 - and.	mod. azur - mal - cup
80	5				3.46	3.15							mod		75 - monz.	monz. with minor and., st. azur - cup, tr py
85	5				1.34	.87								mod		mod. clay - ser - kspar alt., mod. azur - mal, tr cc - py
90	5				.68	.29										sulfide zone, nil lim, tr azur, mod py - cc
95	5				.28	.08										mod. ser - kspar, mod py - cc. tr moly
100	5				.28	.06										as above
105	5				.35	.09										" "
110	5				.29	.03										" "
115	5				.24	.06										" "
120	5				.16	.02										" "
125	5				.24	.06										" "

nal Depth 100'
ollar Elevation
oordinates
clination vertical

ASARCO
GEOLOGIC – ASSAY LOG
Property Copper Butte - Silver Bell

HOLE NO. FR-210
Sheet No. 1
Date Completed 3/21/72
Logged By FTG

th	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration clay	ser	Rock Type	Remarks
-5	5	6"			1.36	1.03									alaskite	fresh, leached, mod mal-ten
10	5	rotary			1.23	1.01										as above
15	5				1.06	.59										fresh, mixed lim-mal-ten and sp py-cc
20	5				.85	.34										as above
25	5				.65	.39	55'						wk			wk clay, tr lim-ten, sp py-cc-cpy
30	5				.73	.31	@									as above
35	5				1.05	.31	0.87									" "
40	5				.76	.18	0.41								38'-monz	" " ; monz, mod greenish clay-ser, mod py-cc-cpy
45	5				.72	.12							mod	mod		monz, asabove
50	5				.52	.10										" "
55	5				.64	.17										" "
60	5				.26	.04										" "
65	5				.16	.02										alt. increasing to strong clay-ser, sp py-cc-cpy
70	5				.36	.04							st	st		as above, sulfides mostly disseminated?
75	5				.18	.04										" "
80	5				.04	.01										" "
85	5				.06	.01										" "
90	5				.07	.01										" "
95	5				.07	.01										" "
100	5				.08	.01										" "

inal Depth 108'
ollar Elevation
oordinates
clination vertical

ASARCO
GEOLOGIC — ASSAY LOG

Property Copper Butte - Silver Bell

HOLE NO. FR-211
Sheet No. 1
Date Completed 3/21/72
Logged By FTG

pth	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration clay	ser	Rock Type	Remarks
8	8	6"													alluvium	
13	5	rotary			.52	.51									alaskite	fresh, leached, sp mal-ten
18	5				.42	.41										as above
23	5				.38	.23										fresh, mixed sp lim-mal-ten and sp py-cc-cpy
28	5				1.90	1.78									25' andesite	as above; andesite, mod mal, tr cup
33	5				2.56	2.50										andesite, st. mal-cup-chry
38	5				1.29	1.25										mod mal-ten
43	5				1.36	1.34										tr chry
48	5				.82	.81	90'									mod mal-ten-chry, tr azur
53	5				1.02	1.01	@									as above
58	5				.69	.69	0.85									" "
63	5				.36	.35	0.78						wk	wk	58'-monz	wk clay-ser, mixed tr lim-mal and tr py-cc
68	5				.39	.31										as above
73	5				.37	.34										" "
78	5				1.09	1.05										wk clay-ser, mod lim-mal-ten-chry, no suls.
83	5				.75	.68										as above with tr CuOx, tr py-cc
88	5				.30	.19										as above
93	5				.65	.41										" "
98	5				.44	.17										" "
103	5				.26	.12										" "
108	5				.31	.08							mod	mod		mod clay-ser-kspar, tr lim-py-cc

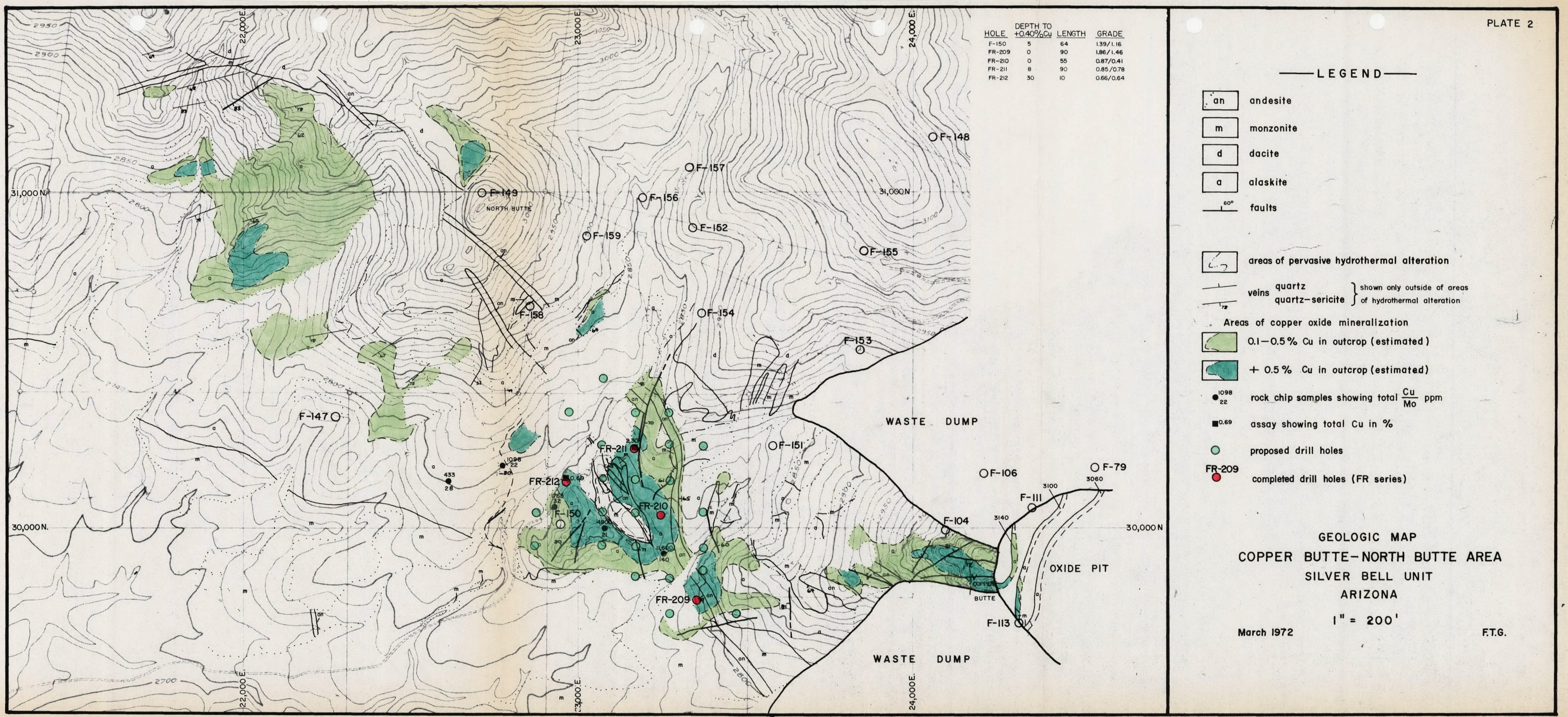
inal Depth 100'
ollar Elevation
oordinates
clination vertical

ASARCO
GEOLOGIC – ASSAY LOG

Property Copper Butte – Silver Bell

HOLE NO. FR-212
Sheet No. 1
Date Completed 3/22/72
Logged By FTG

th	Interval	Core Size	Sp Grav	Core Rec %	Core Assay - % Cu Total	Non-S	Average	Mineralization Oxides	Pyrite	Cpy	Cc	Other	Alteration chlor		Rock Type	Remarks
- 5	5	6"			.26	.25									alaskite	fresh, leached, tr cup
10	5	rotary			.24	.24										as above
15	5				.19	.18										" "
20	5				.28	.27										as above with tr mal-ten
25	5				.14	.14										as above
30	5				.29	.26	10'									" "
35	5				.87	.86	@									as above with mod. mal
40	5				.44	.42	0.66								39'-monz	as above; monz, fresh, leached, tr mal
45	5				.28	.26	~~0.64~~									as above
50	5				.18	.17										" "
55	5				.17	.17										" "
60	5				.14	.13										leached, mod pink kspar (magmatic?), tr mal
65	5				.12	.12										as above, mal. assoc. w. lim-stained rock
70	5				.14	.13										as above, tr blk oxide
75	5				.11	.11							wk			wk chlor-kspar; tr lim, blk oxide, no suls
80	5				.15	.14										as above
85	5				.22	.21										" "
90	5				.11	.09										" "
95	5				.10	.08										" "
100	5				.07	.05										" "



HOLE	DEPTH TO +0.40% Cu	LENGTH	GRADE
F-150	5	64	1.39/1.16
FR-209	0	90	1.86/1.46
FR-210	0	55	0.87/0.41
FR-211	8	90	0.85/0.78
FR-212	30	10	0.66/0.64

mn 2537 DAM

AMERICAN SMELTING AND REFINING COMPANY
SILVER BELL UNIT
Silver Bell, Arizona

J. H. C.

DEC 22 1972

December 20, 1972

MR. R. B. MEEN
TUCSON OFFICE

SILVER BELL UNIT
REVISION OF GEOLOGIC MAPPING SYMBOLISM AT THE SILVER BELL UNIT: JON W. CAMERON

Dear Sir:

Attached is a memorandum by Mr. Cameron suggesting a revision of geologic symbols used in pit mapping.

I have no recommendations in the matter, however, before a change is made I would like for Mr. Courtright and others receiving copies of this memo to offer their comments. If all of the geologists agree that there is a real advantage to the revisions, then I would recommend to you that they be adopted.

Very truly yours,

Original Signed By
D. R. JAMESON

D. R. JAMESON
Superintendent

DRJ:df

Encl.

cc: JHCourtright w/encl.
WLKurtz "
FTGraybeal "
RBCummings "
JWCameron wo/encl.

AMERICAN SMELTING AND REFINING COMPANY
SILVER BELL UNIT
Silver Bell, Arizona

December 11, 1972

MEMORANDUM TO: Mr. D. R. Jameson, Superintendent

Subject: REVISION OF GEOLCGIC MAPPING SYMBOLISM AT THE SILVER BELL UNIT.

Due to the refinement of porphyry copper genesis and hydrothermal zonal concepts developed since initiation of geologic pit mapping at Silver Bell, W. L. Kurtz, F. T. Graybeal, R. B. Cummings and the author recommend revision of the symbols used in the pit mapping. The suggested revised foremat involves retension of many of the earlier symbols along with modification of some earlier symbols (e.g., grades of hydrothermal alteration) and addition of some entirely new symbols (e.g. notation of sulfide ratios and descriptions of vein selvage assemblages).

These revised symbols have been tested in the pit mapping on a trial basis with excellent results. The only real difficulty that exists is that the volumous amount of data would possibly necessitate one overlay where mapping of accumulated bench toes is composited as the mining progresses across a bench. Structure can be reported on one sheet and rock type, alteration and mineralogy on the second sheet. The previous method of preparing composite assay maps will be retained; this map then provides the second overlay and makes a possible total of three sheets to be carried for each bench rather than the previous two sheets.

It has been suggested that these symbols could be used, perhaps with slight modifications to fit particular needs, at Sacaton or other operating properties with similarities to Silver Bell.

J. W. Cameron

Jon W. Cameron
Resident Geologist

JWC:jca

Attach: 4 pages

cc: JHCourtright
WLKurtz
FTGraybeal
RBCummings
File (2)

SILVER BELL MAPPING SYMBOLS: 10/72

STRUCTURE

A. TYPE

I. Faults: 70 6" with thickness note (blue).

II. Barren joints: 70 (blue - Verithin #741).

III. Mineralized joints: 70 (red - Verithin #745).

IV. Oxidized mineralized joints: 70 (brown - #746).

V. Partially mineralized (<50% of joint surface) joint: barren structure plus red parallel tick 70 .

VI. Breccia: △△△△△ in either blue or red if mineralized.

B. FREQUENCY

I. Weak: 1 foot spacing 65 with 0.3" separation.

II. Moderate: 2" to 1 foot spacing 65 with 0.2" separation.

III. Strong: 2" spacing 70 with 0.1" separation.

C. QUARTZ VEINS

I. Note broad bull quartz or other strongly silicified vein zones by continous line in true green #751 over extent of silification: or .

CONTACTS

Geologic, use solid or broken line: black (pencil/ink).

NON-METALLIC ALTERATION MINERALOGY.

A. IGNEOUS ROCKS.

I. Type - color code for each assemblage, overlapping where necessary:

a. Silicification: true green - Verithin #751 .
b. Potassic: (K-feldspar and biotite) lavender - Verithin #737 .
c. Phyllic: (sericite and quartz) orange - Verithin #737 .

d. Argillic: (supergene and hypogene) olive green - Verithin #739½ .

II. Strength - lines drawn along toe of bench or mapping plane:

a. .... weak <10%.
b. — — — — moderate 10 - 30%.
c. ———— strong >30%.

III. Occurrance - disseminated vs. vein:

a. Report written in code color along toe as: total vol. % assemblage/vol. % disseminated, eg., 10/8 (in 724½)=10%(potassic alteration)that is 80% disseminated and 20% in veins.

IV. Vein assemblages:

a. Describe vein selvage assemblage and sequence of zoning with color coded parallel ticks placed along mineralized and barren structure symbols (70 or 70) or with word notes.

V. Paragensis of veins:

a. Note relative ages of veins by color coded vein symbols, eg., - short cross tick assemblages (younger) cuts longer vein assemblages (older) or word note.

VI. Vein thickness:

a. Note vein thickness by dimension written in color code next to joint or vein symbol. 70 .5"

VII. Note estimated percentages of other minerals, eg., barite, chlorite, biotite(primary/secondary), epidote, etc.

B. SEDIMENTARY ROCKS:

I. Strength and type of hydrothemal replacement:

a. Record vol. % gannet/vol. % diopside/vol. % other green silicated (chlorite, serpentine, talc, etc.) in graphite pencil along toe. eg., 30/20/10 = 30% garnet, 20% dioside, 10% green silicates and 40% original rock constituents or other constituents.

II. Vein assemblages and paragensis:

As for igneous rocks.

METALLIC MINERALOGY.

A. DOMINANT SULFIDES - pyrite, chalcopyrite, chalcocite:

I. Note estimated volume percent of dominant sulfides in red between areas of significant changes as: 3/.1/.3 . Note estimated volume percent of pre-existing sulfides in oxidized zones by brown note: 3/.1/.3 .

II. Note estimated volume percentage of dissemination verses vein associated sulfides by using a fourth volume percent in conjunction with the above, eg: 3/.1/.6/2 = 3% pyrite/.1% chalcopyrite/.6% chalcocite/ of which 2% is disseminated and 1.7% is vein associated.

III. If relative amounts of disseminated pyrite, chalcopyrite and chalcocite differ substantially, make pencil notation.

IV. Make pencil notation of average thickness of sulfide veins.

1/4" ∩7°

V. Make pencil notation of percentages of other metallics, eg., magnetite, hematite, sphalerite, galena, bornite, etc.

MISCELLANEOUS.

Note miscellaneous features such as zenoliths, vugs, rock textures, etc., with graphite pencil notes.

GRADE CONTROL FOR ENGINEERING

A. Copper grade(in % total Cu)

0.2% Cu in red #745
0.2% Cu in red #745
0.4% Cu in red #745
0.6% Cu in red #745
0.8% Cu in red #745

ie., 1/10th" per 0.2% Cu.

B. Oxide copper grade(in % total Cu)

0.2% oxide Cu in sepia brown #746
0.2% oxide Cu in sepia brown #746
0.4% oxide Cu in sepia brown #746
0.6% oxide Cu in sepia brown #746
0.8% oxide Cu in sepia brown #746

Pass on to Whit Cameron Silver Bell

J. H. C.

JAN 4 1973

RECEIVED
DEC 20 1972
EXPLORATION DEPT.

61 Prospector Village
Golden, Colorado 80401
11 December 1972

Dear Mr. Courtright,

I want to take this opportunity to thank you for all your help in setting up my visit to the Silver Bell unit so I could collect samples for my leached capping study.

I would also like to acknowledge the very fine help of the resident geologist, Mr. Whit Cameron, during my stay at Silver Bell.

Thank you again.

Sincerely,

Edward Krish

Edward Krish

J. H. C.
OCT 11 1972

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

October 3, 1972

Memorandum for R. B. Meen
R. S. Herde

From: W. L. Kurtz

Silver Bell
Possible Reserves
Southwest Oxide Pit

I spent the day yesterday at Silver Bell in the company of Messrs. Cameron, Graybeal and Cummings. The purpose was to lay out a program for remapping the Oxide and El Tiro pits (to be done by Mr. Cummings) and for the continued pit mapping by Mr. Cameron. This new mapping system will record features that will allow for better geological interpretation of the ore occurrence at Silver Bell and help Mr. Graybeal's district-wide evaluation.

A matter, upon which I feel I must comment, came up during the day: the placement of waste and/or leach dumps over areas before determining their ore potential. From an exploration viewpoint this is inexcuseable but from a mining viewpoint quite justifiable ---- somewhere between the twain should meet.

The area of paramount concern lies north of the precipitation plant and southwest of West Extension #2 of Oxide pit. Mr. Cameron drew attention to this area in July 1970 (Rpt: Drill Hole Data of the Silver Bell District) and specifically recommended drilling August 14, 1972 in a memorandum "Proposed Drilling and Estimated Ore Reserves in Southwest Oxide Pit -- Precipitation Plant Area, Silver Bell Unit". Mr. Cameron estimated possible reserves (based on five drill holes) of 2 million tons averaging 0.79/0.27 with stripping ratio of 0.62/1.00. This reserve, if indeed it does exist, will certainly help Silver Bell's life and provide additional feed for either the oxide plant or the present mill.

The current leach dump under construction is rapidly covering this area. With the inherent problems of drilling through old dumps, it seems most reasonable to me to determine the future ore potential of this area now. Then, armed with this information, the engineers can determine where it is most economical (in the long term) to construct the leach dump. As pointed out by Mr. Cameron, the oxide plant might process the leach dump material. (Efficiency of dump leaching suggests that even the "worked out leach dumps" might provide a profitable feed for the oxide plant.)

In any event, no waste dump should be allowed to cover the area discussed until its potential is known. The diamond drill currently at Silver Bell should be available in a few days and it wouldn't take much time or money to complete the recommended 700' of drilling.

W. L. K

W. L. Kurtz

WLK:lad

cc: JJCollins
JHCourtright

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

September 29, 1972

Mr. D. R. Jameson
Silver Bell Unit

THESIS PROJECT
Silver Bell

Dear Don:

Mr. Harold Courtright has asked that we permit Mr. E. J. Krish to carry out a study which would involve analytical work for trace elements from the capping and underlying sulfides at Silver Bell.

It is my understanding that Mr. Krish would do this work around the first part of November of this year. I understand that the project would take approximately one or two weeks. Would you please make arrangements so that Mr. Krish can conduct his project.

Very truly yours,

Roy S. Herde

ROY S. HERDE
Assistant Manager

RSH:nb

cc: JHCourtright
WLKurtz

EJKrish
61 Prospector Village
Golden, Colorado 80401

Silver Bell
&
Thesis Support

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

September 28, 1972

MEMORANDUM FOR: R.B. Meen

SILVER BELL
THESIS PROJECT

Last year Earl Ingerson, Professor at the University of Texas, wrote proposing that E.J. Krish (now at Colorado School of Mines) conduct a study of leached capping at Silver Bell as a master's project. As you will see in the attached correspondence, I did not offer much encouragement; however, Mr. Krish phoned yesterday asking if permission would be granted to carry out the study which would involve analytical work (for trace elements) on the capping and on underlying sulphides (in drill cores, or sample rejects). He would also need a print of existing 200 scale topog to use as a base map.

Although this project appears to fall in the "pure research" category, I believe permission should be granted to further good public relations.

If you approve, please so advise Mr. Jameson with a copy to E.J. Krish, 61 Prospector Village, Golden, Colorado 80401.

J.H. Courtright
J.H. Courtright

JHC:kre
Encl.
cc: W.L. Kurtz w/encl.

9-29-72 – Phoned Krish – estimates one to 2 weeks – starting Nov. 1st.
– I advised Roy Herde – he will approve project.

THE UNIVERSITY OF TEXAS AT AUSTIN
AUSTIN, TEXAS 78712

Department of Geological Sciences

RECEIVED
MAR 2 . 1972
EXPLORATION DEPT.

J. H. C.
MAR 27 1972

March 24, 1972

Mr. Whit Cameron
ASARCO
Silver Bell Mine
Silver Bell, Arizona 85270

Visitors

Dear Whit:

When we were at Silver Bell last week you did a wonderful job of giving us maximum information in minimum time during our whirlwind visit there. I certainly enjoyed it and got a lot out of it, even though, in a way, I was just an interloper on the trip.

However, I am on Ed Krish's committee at the School of Mines and I am just as interested in his project as though I were directing all of his research first-hand.

We were very much impressed with what we saw at Silver Bell. It seemed to us to be the best locality we have seen or discussed for Ed's problem. Also, you evinced more interest in helping him out than anyone else has and we are both looking forward to his getting back there for collecting.

I very much hope that at that time or not much later you will have opportunity to start working on some of the interesting and important problems we discussed. They would certainly have general application to many other similar deposits and it seems to me you are in a position to make a considerable contribution to the literature, if things work out just right. I hope they do.

Sincerely yours,

E. I.

Earl Ingerson

EI/j

cc: Mr. J. H. Courtright

~~Rare Elements~~ Silver Bell & Thesis Support
JHC Secy File

June 18, 1971

Mr. Earl ~~E~~Ingerson
Dept. of Geological Sciences
University of Texas
Austin, Texas 78712

Dear. Mr. ~~E~~Ingerson:

Please accept my apology for the delay in answering your letter of May 6, also for the brief nature of this reply.

Frankly, I'm not very optomistic regarding the outcome of a study of rare elements in porphyry copper capping. To achieve any meaningful results it would, in my opinion, require a large undertaking involving several deposits, sampling of many drill cores, etc. Accordingly, I am not inclined to recommend financial support, since this is a project that should be undertaken by the USGS, if they think it's worthwhile. However, I believe arrangements could be made for the resident geologist at Silver Bell to assist in selecting locations and taking samples, if Mr. Krish wishes to proceed.

Yours very truly,

J. H. Courtright

JHC/jmm

cc: WLKurtz

J. H. C.

MAY 25 1971

~~FDS~~ ~~WES - to L K~~

Verbal Comment?

THE UNIVERSITY OF TEXAS AT AUSTIN

AUSTIN, TEXAS 78712

Department of Geological Sciences

May 6, 1971

W.E.S.
MAY 26 1971

Mr. J. H. Courtright
Valley National Bank
Tucson, Arizona

Dear Mr. Courtright:

Toward the end of last semester as the culmination to a graduate seminar on the geochemistry of ore formation, I took a group of students on a trip to Mexico to visit some of the mines in San Luis Potosi, Durango, Zacatecas, and Chihuahua. For some of the deposits (especially copper) we discussed the possibility of a new approach to the problem of determining from a geochemical study of the oxidized zone the probable nature of the underlying deposits. Actually, the only innovation consists in looking at assemblages of rare elements that have not commonly been considered in the past. On theoretical grounds and from some recent determinations of these rare elements in copper sulfides, there seems to be reason to believe that this approach might yield worthwhile results.

One of the students in the group who went on the trip, Ed Krish, is very much interested in the possibility of pursuing this problem for a thesis. He has been accepted for graduate work at the Colorado School of Mines in Golden where, presumably, he will work with Hal Bloom, although I shall probably direct his thesis research from here.

I have discussed this approach with some of my ex-colleagues in the Geochemical Prospecting Group of the U. S. Geological Survey in Denver. They agreed that the suggested approach appears worthwhile, but were unable to think of any districts in Colorado where it might be applied. They referred me to Cy Creasey, also of the Survey, and I called him to see whether he could suggest specific localities in Arizona or New Mexico. He suggested that I write to you about the possibility of doing work of this kind at the Silver Bell. I should appreciate it, therefore, if you could let me know whether you think that the Silver Bell would be a good place to study this problem and, if so, whether it might be possible to make arrangements for Krish to make the study. Krish is married, has one child, and no independent income, so it would be very helpful to him if the company could support the work financially. If not, perhaps it would be possible for someone to help him get oriented, assist in collection of samples, etc. I should appreciate it very much if you could give me your frank reaction to these possibilities.

I am enclosing a very brief write-up of what Ed would propose to do; I thought it would be better to look at it in his words rather than to have me to go into more detail in the letter.

He will be working with a geochemical prospecting party of the U. S. Geological Survey during the summer so would not be ready to undertake any field work for his thesis before next fall.

If something like this appears feasible, perhaps we should discuss details by phone. My number here is Area Code 512, 471-7301, but for most of the summer I shall be with Esso Production Research Company in Houston, Area Code 713, NA 2-4222.

Thank you.

Sincerely yours,

Earl Ingerson

Earl Ingerson

EI/j

Encl.

Proposal for Study of Rare Elements in Gossan (E. Krish)

I propose to study a geochemical exploration technique designed to distinguish between bodies of primary copper sulfides and cupriferous iron sulfides that are buried beneath oxidized caps containing secondary copper carbonates, hydroxides, silicate, etc., in the oxidized zones over the two kinds of deposits. The proposal is to study the amounts and distribution of rare elements that are probably associated with copper in its sulfides.

It has been observed that the concentrations of certain rare elements such as gallium, germanium, indium, thallium, and cadmium, along with the more commonly recognized associates of copper -- Ni, Co, Ag, Pb, Zn -- are commonly greater in chalcopyrite than in pyrite (Vlasov, 1964). The oxidized zone overlying a body high in chalcopyrite should also be richer in these rare and more common elements than the oxidized zone overlying a body of cupriferous pyrite, containing little or no chalcopyrite. It is felt that by studying two productive copper sulfide deposits and two nonproductive iron sulfide deposits, this hypothesis could be tested, at least in preliminary fashion.

The productive bodies would be sampled across the oxidized zone and vertically to see how the element concentration varies. Barren bodies would also be sampled surfically and vertically. To estimate relative mobilities and to check the size of the aureole for various elements, sampling would be extended beyond the oxidized cap into the surrounding country rock. The samples would be analyzed primarily by optical spectrographic methods.

References

1. Fleischer, M., 1955, Minor Elements in Some Sulfide Minerals, in Bateman, Alan M., editor, Economic Geology, 50th Anniversary Volume, Part II: Society of Economic Geologists, p. 970-1024.

2. Goldschmidt, V. M. and Cl. Peters, 1933, Zur Geochemie des Germaniums: Ges. Wiss. Gottingen, Nachr., Math.-Phys. Klasse, p. 141-166.

3. Hawley, J. E. and Ian Nichol, 1961, Trace Elements in Pyrite, Pyrrhotite and Chalcopyrite of Different Ores; Econ. Geol., v. 56, p. 467-487.

4. Vlasov, K. A., editor, 1964, Geochemistry and Mineralogy of Rare Elements and Genetic Types of Their Deposits, Vol. I, Moscow, English translation by Isreal Program for Scientific Translations, Jerusalem, 1966.

J. H. C.
AUG 15 1972

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

August 14, 1972

Mr. J. J. Collins
Director of Exploration
New York Office

Silver Bell, Arizona

Dear Sir:

In reply to your letter of August 4th and Mr. Desvaux's memorandum to you of August 3rd, we are aware of the possibility of in-situ leaching of any low-grade copper in the walls of the pits and also, though less likely, the leaching of low-grade primary beneath the pits.

One of our objectives in the restudy of the mineralization at Silver Bell was to determine if high-grade primary ore might exist in depth. To date we have not had the time or manpower necessary to make the appropriate alteration and mineralization studies to propose any deep drilling at Silver Bell.

Very truly yours,

W. L. K

W. L. Kurtz

WLK:lad

cc: JHCourtright
FTGraybeal

J. H. C.
AUG 28 1972

RECEIVED
AUG 7 1972
EXPLORATION DEPT.

Air Mail

August 4, 1972

Mr. W. L. Kurtz
Asarco - Tucson Office

file

Silver Bell, Arizona

Dear Sir:

When, or if, the occasion seems appropriate you might act on the subject of the attached memorandum by J. V. Desvaux on leaching at Silver Bell and let me know your views.

Since high-grade primary ore has been found at depth in two other districts, do you propose to revive the idea of deep drilling at Silver Bell?

Very truly yours,

Original Signed By
John J. Collins
John J. Collins

Encl.

cc:JHCourtright - w/att.

New York, August 3, 1972

MEMORANDUM FOR: Mr. J. J. Collins

Silver Bell, Arizona
In Situ Leaching

Mr. Graybeal has reported on the reserves of non-sulfide copper in predominently sedimentary rocks at both El Tiro and Oxide. There may be another possibility if in situ leaching could be applied to the low-grade primary copper beneath the open pits, and, possibly in the pit walls (which may include non-sulfide).

I understand that Dowell has hinted at knowledge of acidic reagents for recovery of copper from chalcopyrite. If true, they might be invited to contract for an experimental study of this sort at Silver Bell.

J. F. Desvaux

J. H. C.

APR 27 1972

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

April 26, 1972

Mr. J. J. Collins
Director of Exploration
New York Office

file

Oxide Copper
Silver Bell District, Arizona

Mr. Graybeal has prepared a summary of the work done by the Silver Bell Unit's staff and himself on the development of oxide copper reserves at Silver Bell.

14.9 million tons averaging 0.86 total copper is proven and an additional 3.5 million tons is inferred in three areas which have been recommended for drilling. In one of these areas, the Copper Butte area (see Fig. 1), four drill holes were put down on Mr. Graybeal's recommendation and all intersected significant amounts of +.8 total copper.

Additional drilling has been recommended to Silver Bell Unit to determine whether an ore reserve can be developed in the Copper Butte area.

W. L. Kurtz
W. L. Kurtz

WLK:lad
Attach.

cc: RBMeen -- w/attach.
DRJameson -- "
AJKroha -- "
GWBossard -- "
JHCourtright -- "
FTGraybeal -- w/o attach.

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

April 17, 1972

MEMORANDUM

TO: W. L. Kurtz

FROM: F. T. Graybeal

Development of Additional Non-Sulfide Copper Reserves at Silver Bell

SUMMARY

The evaluation of non-sulfide copper deposits at Silver Bell has established a proven reserve of 14,913,710 tons averaging 0.86/0.67% Cu at a 0.40% Cu cutoff. Approximately 90 percent of this material is in carbonate-rich sedimentary rock. An additional 3,500,000 tons is inferred from geologic mapping and drilling, and proposals recommending further exploration of these areas have been submitted.

INTRODUCTION

The forthcoming availability of large quantities of sulfuric acid has renewed interest in the possibility of leaching the carbonate-rich non-sulfide copper reserve in the El Tiro East Extension #2 (Imperial) area at Silver Bell. The high grade of this material offers a good chance of profitable treatment while, at the same time, consuming much of the acid now being produced at the Hayden smelter. However, as the tonnage appeared limited, an evaluation was made of possible additional non-sulfide copper reserves.

When this project was initiated, the non-sulfide copper reserves at Silver Bell included only sedimentary material in the Imperial area which exceeded 0.40% Cu and which had to be removed to expose underlying sulfide ore. To increase these reserves, the assumption was made that mining cutoffs now used for sulfide ore could also be applied to non-sulfide material, whether or not underlying sulfides are present. This would require a leach recovery of 70-80 percent, roughly equivalent to that of the Silver Bell concentrator. Recoveries in this range have been obtained in preliminary tests of carbonate-rich material and are predicted for the new San Xavier plant.

It was also assumed that increases in reserves and the greater recovery gained by vat as compared to heap leaching were more important considerations than acid consumption. Therefore, an evaluation was also made of non-sulfide copper in igneous rocks, material which would otherwise go to the leach dumps.

The complete cooperation of Messrs. D. R. Jameson, R. A. Barnes, W. C. Waidler, and J. W. Cameron of the Silver Bell Unit is gratefully acknowledged.

PROVEN RESERVES

The tonnage, grade and location of the different areas are shown on Table 1 and Figure 1. The reserve estimates are reported at a 0.40% Cu cutoff and were cleared through Mr. R. A. Barnes as requested by Mr. D. R. Jameson.

The reserves in El Tiro East Extension #1 and #2 are entirely in carbonate-rich sedimentary rock. All material from the East Extension #1 and approximately one-half that in East Extension #2 has been mined and stockpiled. The East Extension #2 zones average 21.5 percent calcite.

The reserves in the El Tiro North Extension are entirely in carbonate-poor igneous rock. This material will be removed during stripping of the underlying sulfide ores.

The reserves in the El Tiro North Non-sulfide Addition are mostly in carbonate-poor igneous rock. This material overlies roughly 2 million tons of sulfides averaging 0.65% Cu which can be mined only if the copper oxides become ore and thereby carry part of the stripping.

EXPLORATION TARGETS

Material in this category includes areas where scattered prior drilling and mapping have indicated the presence of mineable tonnages of copper oxide mineralization. Proposals recommending additional drilling in these areas have already been submitted.

The Billy and Mammoth areas, adjacent to El Tiro East Extension #2, have a combined potential of about 1.5 million tons, all in carbonate-rich sedimentary rock. The Mammoth area also contains 30 bench polygons of +0.40% Cu sulfide material which is not presently ore due to a high stripping ratio.

The Copper Butte area, west of Oxide pit, was estimated from geologic mapping to contain 1.5-2 million tons of ore grade material, all in carbonate-poor igneous rock. Four recently completed rotary drill holes support this estimate and further drilling has been recommended.

OTHER COPPER OXIDE MATERIAL

The waste dumps at Silver Bell contain approximately 31 million tons averaging at least 0.10% Cu in igneous rock which is topographically suitable for heap leaching. As of Jan. 1, 1972 the tailings ponds contained 54,707,150 tons averaging 0.195/0.109% Cu; however, the milling department feels that this grade is insufficient to support handling of this material.

SUMMARY

At the present time there are 14,913,710 tons averaging 0.86/0.67% Cu currently listed as non-sulfide copper reserves, of which approximately 90 percent is in carbonate-rich sedimentary rocks. Small additional amounts of similar material may be added to this figure during the course of mining, if non-sulfide copper material is established as ore by the current feasibility studies.

If the proposed drilling projects are successful, approximately 3.5 million tons may be added to the proven reserves. The remaining copper oxide deposits present on the Silver Bell property are too small to be of exploration interest. Other copper oxide deposits outside the present property limits will be evaluated as part of the overall study of the Silver Bell district.

F. T. Graybeal

F. T. Graybeal

FTG:lad
Attachs.

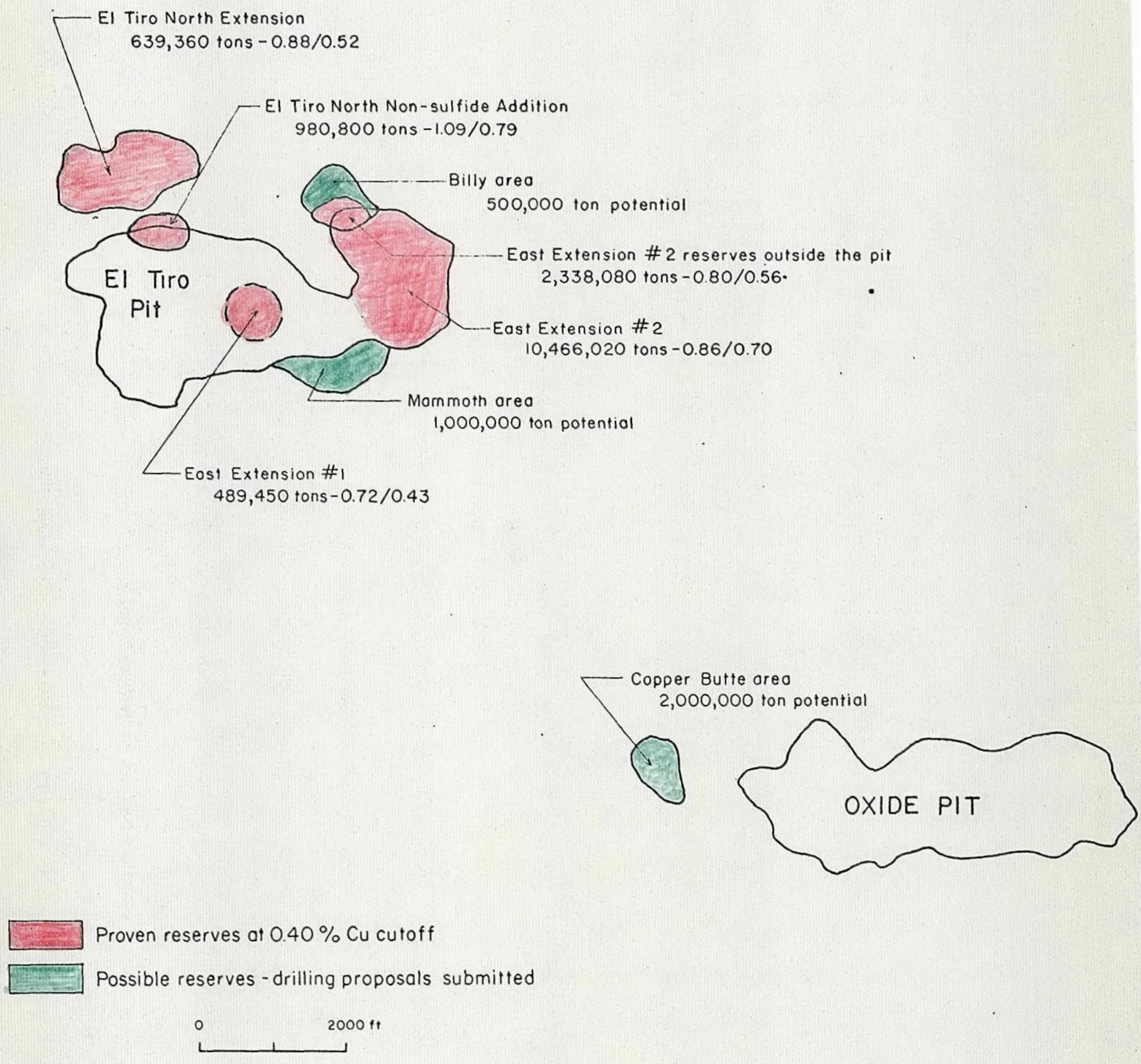
TABLE 1: Non-sulfide copper reserves at Silver Bell

area	rock type	tonnage	grade
El Tiro East Extension #2 (inside pit)	sedimentary	10,466,020	0.86/0.70
El Tiro East Extension #2 (outside pit)	sedimentary	2,338,080	0.80/0.56
El Tiro East Extension #1	sedimentary	489,450	0.72/0.43
El Tiro North Extension	igneous	639,360	0.88/0.52
El Tiro North Non-sulfide addition	igneous	980,800	1.09/0.79
	Total	14,913,710	0.86/0.67

TABLE 2: Non-sulfide copper exploration targets at Silver Bell

area	rock type	estimated tonnage +0.40% Cu
El Tiro East Extension #2	sedimentary	1,500,000
Copper Butte	igneous	2,000,000

Figure 1



SILVER BELL UNIT

AREAS CONTAINING PROVEN AND POSSIBLE NON-SULFIDE COPPER RESERVES

F.T.G. April 1972

MVK 2549

cpy file

S-1.2

W. L. K.

MAR 28 1972
Silver Bell FTG

AMERICAN SMELTING AND REFINING COMPANY
SILVER BELL UNIT
Silver Bell, Arizona

March 27, 1972

J. H. C.
MAR 29 1972

file

MR. R. B. MEEN
TUCSON OFFICE

SILVER BELL UNIT
NON-SULPHIDE COPPER RESERVES

Dear Sir:

When Fred Graybeal made his evaluation of additional oxide copper potential at Silver Bell on March 8th, an area between El Tiro Pit proper and El Tiro North Extension was established as containing 1,000,000 tons of non-sulphide ore.

Mr. Barnes has now completed a reserve calculation for this area with the results tabulated on the attached memorandum. The indication is that 2,141,120 tons of sulphide ore with a grade of 0.65% Cu would be developed if the 980,800 tons of non-sulphide material is found to be ore, a definite plus factor for this area.

Very truly yours,

Original Signed By
D. R. JAMESON

D. R. JAMESON
Superintendent

DRJ:df

Encl.

cc: WLKurtz w/encl.
FGraybeal "
GWBossard "
BLRickman "
WTBarlow "

MAR 24 1972

D. R. J.

AMERICAN SMELTING AND REFINING COMPANY
SILVER BELL UNIT
Silver Bell, Arizona

March 21, 1972

MEMORANDUM TO: Mr. D. R. Jameson, Superintendent

Subject: POSSIBLE SOURCE OF +0.4% NON-SULFIDE COPPER ORE

The area between the El Tiro Pit and the El Tiro north Extension was suggested as a possible source of +0.4% non-sulfide copper. A reserve was calculated and the results are as follows:

NON-SULFIDE ORE

+0.8%	+0.6%	0.4%	-0.4%
556,800 @ $\frac{1.48}{1.14}$	824,000 @ $\frac{1.21}{.91}$	980,800 @ $\frac{1.09}{.79}$	6,195,680

SULFIDE ORE

+0.8%	+0.6%	+ 0.4%
435,520 @ 0.92	1,345,920 @ 0.74	2,141,120 @ 0.65

If the non-sulfides become a commercial ore then it appears that this area could be mined someday for both the sulfides and non-sulfides with a stripping ratio of 1.98 to 1.00. The ore from the East Extension #2 will pass over this area on the way to the mill, so mining of this area should be delayed as long as possible.

The North Extension also contains some +0.4% non-sulfides:

+0.8%	+0.6%	+0.4%
208,320 @ $\frac{1.45}{.88}$	430,400 @ $\frac{1.06}{.70}$	639,360 @ $\frac{.88}{.52}$

R. A. Barnes

R. A. Barnes

RAB:jca

JHC

ASARCO

AMERICAN SMELTING AND REFINING COMPANY
MINERAL BENEFICIATION DEPARTMENT
P. O. BOX 5747, TUCSON, ARIZONA 85703

W. L. K.
MAR 17 1972

RECEIVED
MAR 14 1972
A. J. KROHA

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

G. W. BOSSARD
DIRECTOR

March 14, 1972

Mr. A. J. Kroha, Manager
Southwestern Ore Purchasing Department
Building

file

J. H. C.
MAR 17 1972

SILVER BELL UNIT
Acid Leaching of Oxide Carbonate Ores

Dear Sir:

Reference is made to your request of this date for preliminary information concerning the results of our program for the above subject. It is understood that such information is to be used for estimating the delivered price (F.O.B. Silver Bell) for sulfuric acid required for such an operation. Under the present acid price schedule received from you by the undersigned on November 8, 1971, it appears that operation of such a plant would not be feasible, at the acid prices listed through 1982.

Very preliminary laboratory results indicate a recovery of 75 percent in a relatively coarse grind (-10 mesh) and short leaching period (1-2 hours). Acid consumption still appears to be in the neighborhood of 400 pounds/ton leach feed. A finer grind does not appear to be justified as recovery is not materially increased and the fine material is difficult to handle. Therefore, it appears the flow sheet would be simple—several stages of crushing to minus 3/4-inch followed by grinding to minus 10 mesh, agitation leaching and counter-current decantation to obtain a pregnant solution from which the copper would be recovered by launder precipitation as designed for San Xaver.

The attached data sheets show (1) the estimated total operating costs, and (2) the indicated outcome under the conditions listed. Please bear in mind these figures are based on a small amount of current laboratory results and past experience with similar studies. However, they should be close enough for your purposes and I would not expect them to vary much from our final data.

The outcome calculations based on a 4,000 tpd operation indicate that the acid price (F.O.B. Silver Bell) required to justify such a project would be in the neighborhood of \$5.00/short ton. At this price the indicated return would be approximately 13 percent after taxes. An acid price of \$6.00/ton reduces the return to only 11 percent.

Yours truly,

G.W. Bossard

G.W. Bossard
Director

GWB:dh
Attachments (2)
cc: TAS - w/atts
NV - "
RBM - "
3-15-72

ATTACHMENT NO. 1

SILVER BELL ACID LEACH PROJECT

TOTAL OPERATING COST BASED ON VARIOUS ACID PRICES

Item	Acid Price F.O.B. Silver Bell $4.00/ton	$5.00/ton	$6.00/ton
Operation Supplies			
Acid	$0.80	$1.00	$1.20
Iron	0.30	0.30	0.30
Subtotal No. 1	$1.10	$1.30	$1.50
Maintenance Supplies	0.10	0.10	0.10
Labor and Supervision	0.20	0.20	0.20
Power	0.05	0.05	0.05
Tailing Disposal	0.05	0.05	0.05
Mining or Reclaiming	0.25	0.25	0.25
Subtotal No. 2	$1.75	$1.95	$2.15
Indirects	0.50	0.50	0.50
Total Costs	$2.25	$2.45	$2.65

ATTACHMENT NO. 2
OUTCOME CALCULATIONS

Assumptions

4,000 tpd = 1.44 X 10^6 tpy

Mill Feed = 0.70% Cu

Mill Recovery = 75%

Annual Production = 15,120,000 lbs Cu

Value Annual Production = $6,048,000
(52¢-12¢ = 40¢ NSV)

Estimated Ore Reserves = 19,000,000 tons

Assumed Write-Off Period - 13.2 years

Capital Cost - $12,000,000

Operating Capital - $1,000,000

	Acid Cost - F.O.B. Silver Bell		
	$4.00	$5.00	$6.00
Gross Value/Year	$6,048,000	$6,048,000	$6,048,000
Total Operating Cost	3,240,000	3,528,000	3,816,000
Operating Profit	$2,808,000	$2,520,000	$2,232,000
Depreciation ($13,000,000 ÷ 13.2 years)	985,000	985,000	985,000
	$1,823,000	$1,535,000	$1,247,000
Depletion @ 50%	912,000	768,000	624,000
Federal Income Tax @ 50%	456,000	384,000	312,000
Net Profit After Taxes	$2,352,000	$2,136,000	$1,920,000
Capital Recovery Factor	0.1809	0.1643	0.1476
Estimated Return on Investment	15%	13%	11%

Silver Bell

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

Tucson, Arizona

MEMORANDUM FOR: J.J. Collins

MORENCI

Enclosed is a copy of a paper given at the recent San Francisco meeting. The longitudinal section on page 26 is of considerable interest in that it shows a "2nd generation" chalcocite blanket extending beneath the low grade primary mineralization exposed in Chase Creek, and ore grade (.60% Cu) primary mineralization beneath the Morenci pit bottom. As depicted, this ore is in the low-pyrite potassic zone underlying the phyllic zone (high pyrite) within which the chalcocite blankets were formed.

The chalcocite under Chase Creek is probably due to lateral migration of solutions, but more important is the disclosure of primary ore at depth which adds to the mounting evidence of vertical zoning in porphyry copper deposits. This theory was partially tested at Silver Bell over 3 years ago with one hole being drilled in each pit to depths of around 1500 feet. A careful review of the results and a further study of alteration patterns should be made to determine if additional, or deeper, drilling is warranted.

J.H. Courtright
J.H. COURTRIGHT

JHC:kre

Encl: as noted

cc: Norman Visnes w/encl.
R.B. Meen w/encl.
W.L. Kurtz w/o encl.

(file under both Morenci and Silver Bell)

SOCIETY OF MINING ENGINEERS of AIME

PREPRINT NUMBER 72-I-47

ORE GENESIS IN THE MORENCI-METCALF DISTRICT

Jackson M. Langton
Chief Geologist
Phelps Dodge Corporation
Morenci Branch
Morenci, Arizona

This paper is to be presented at the AIME Annual Meeting - San Francisco, California - February 20-24, 1972.

INTRODUCTION

The Morenci-Metcalf district is located on the southern slope of the White Mountains in Greenlee County, Arizona. Both porphyry copper deposits are four to six miles northwest of Clifton, the county seat, and the new Metcalf mine is situated approximately one mile northeast of the Morenci open pit (Figure 1). Chase Creek, a south-flowing tributary of the San Francisco River, dissects the district and separates the two ore bodies.

More than 1,200 exploration and development drill holes have been completed in the district and the Morenci-Metcalf ore bodies have been delineated on a 400-foot grid. Recently initiated drilling programs have revealed new data about deeper protore and associated hypogene alteration. This information, correlated with surface mapping and petrographic studies, was utilized to propose a plausible geochronologic sequence for this region. The reasoning behind this study has been helpful in locating new ore beneath leached capping indicative of only protore mineralization.

The scope of this paper is to establish a practical solution to a highly theoretical problem of ore genesis and to familiarize the reader with stratigraphic, structural, and mineralogic events responsible for localizing ore in this district. Continued research will possibly alter the proposed time span and relative displacements, but it is doubtful that the order of events will vary significantly. Geochronologic conclusions are therefore presented as general hypotheses and additional geologic mapping,

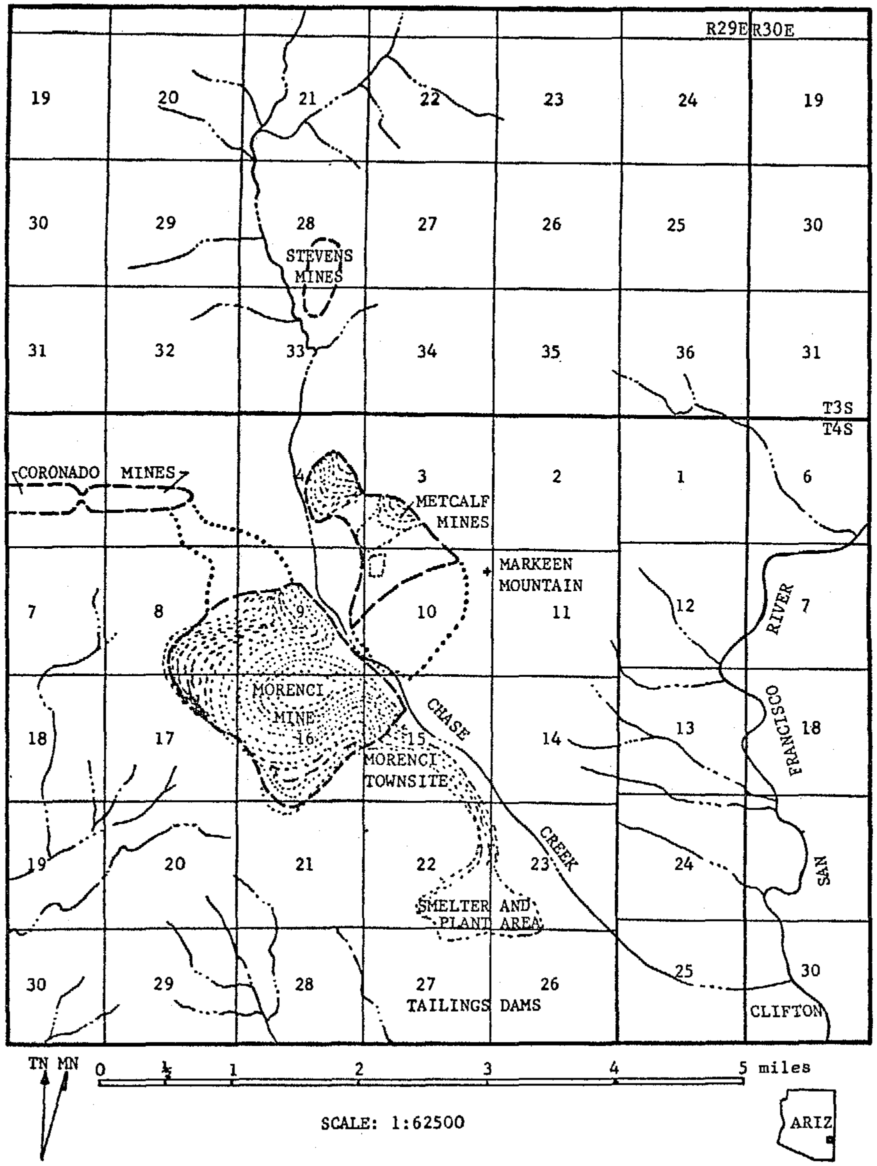


FIGURE 1 : THE MAJOR ORE BODIES MINED OR MINABLE IN 1971

drilling, and geochronometric dating will be needed to more accurately test the proposed events.

SUMMARY

Substantial evidence supports the theory that major fractures, high-angle faults, and overthrusts in this region were initially caused by a Late Precambrian-Early Paleozoic stress field, principally from the north. These major fractures and faults were reactivated in Late Paleozoic-Early Mesozoic time which completed the structural framework and set the stage for the Laramide Orogeny.

Excluding an interruption by diabase dikes and sills, Paleocene-Eocene magmas invaded the preexisting structures and became progressively more sialic in composition and nearer to the surface with each subsequent injection. The last sialic intrusion was highly explosive and rendered the country rocks more permeable for hypogene and supergene activity. Widespread dilation, instigated by uplift and subsequent magma intrusion, caused considerable extension to the northwest and southeast. Although information about primary ore is meager, a major locus of hypogene alteration and mineralization appears to be centered around the south and southeast periphery of the youngest granite porphyry stock. A strongly potassic, sulfide-deficient core has been recognized and is telescoped by a strongly pyritic, phyllic zone which in turn is enveloped by widespread propylitic and argillic alteration.

A uniform supergene chalcocite blanket formed during

pre-Miocene (Late Eocene) time in the upper quartz-sericite (phyllic) zone. Gentle uplift and erosion continued into the Oligocene causing the blanket to be partially leached and copper to be redeposited lower in the phyllic zone. This stage is represented by leached capping over the entirety of the Morenci ore body and over the northeast part of the Metcalf deposit. Possible lateral migration of supergene solutions was contemporaneous with extrusion of Oligocene and Miocene volcanics and a swelling water table.

Rapid uplift on the Metcalf side of the extensive chalcocite horizon caused the water table to drop, changing the gradient southwest toward Chase Creek. Water migration was probably too fast in the southwest portion of the Metcalf deposit to allow time for protore enrichment directly beneath the elevated chalcocite blanket. Deeper in the protore, however, stability of the water table is evidenced by chalcocite-covellite replacement of chalcopyrite which reflects the Late Miocene-Early Pliocene enrichment. Considerable lateral enrichment is again implied during this Basin and Range faulting.

Gila Conglomerate was intermittently deposited with recurrent gravity movement on the San Francisco Fault. Fanglomerates and talus from Chase Creek and the footwall side of the fault reflect one depositional environment whereas lake gravels and fluvial sands represent the San Francisco River facies. These activities were the last geologic events to influence economic aspects of the copper deposits. It is generally accepted that all

of the enrichment blankets in this district are currently being destroyed by erosion or being oxidized in place.

GENERAL GEOLOGY

Only a brief summary and comments on the igneous and sedimentary units are presented here and the reader is referred to Lindgren (1905) and Moolick and Durek (1966) for detailed treatises on the descriptive geology of the district.

PRECAMBRIAN

The basement complex is comprised of four significant and separately mappable units, all of which host information concerned with the Precambrian stress field. Probably the oldest formation is the Pinal Schist-Metaquartzite (P€p), although only an overthrust relationship has been established with the Morenci Granodiorite (P€grd).[1] The Pinal Formation crops out near Pinal Point (Figure 2) and remnants of large recumbent folds with general east-west axes reflect a regional, north to south principal stress orientation. The Pinal was probably intruded by the widespread granodiorite pluton, possibly during the Early Mazatzal Revolution.

Equigranular Metcalf Granite (P€gr) is the youngest Precambrian pluton recognized in the district to date.[2] It clearly

(1) "Morenci" Granodiorite has not been used in older literature and is therefore established in this paper.

(2) "Metcalf" Granite has not been used in older literature and is therefore established in this paper.

72-I-47

72-I-47

New Mexico: N. M. Bur. of Mines and Mineral Resources

[redacted]

[redacted]

CPY FTG, WLK, JHC

S-3.2.2

AMERICAN SMELTING AND REFINING COMPANY
SILVER BELL UNIT
Silver Bell, Arizona

W. L. K.
FEB 15 1972

February 11, 1972

J. H. C.
FEB 16 1972

MR. R. B. MEEN
TUCSON OFFICE

File

SILVER BELL UNIT
ACID LEACH OF EAST EL TIRO
SEDIMENTARY OXIDE ORES

Dear Sir:

Following receipt of Mr. D. E. Crowell's memorandum on the above subject and realizing that feasibility studies were planned on the treatment of a certain estimated ore reserve, I requested that any tons and grade of ore used or thought about be cleared through the Chief Engineer, Mr. Robert Barnes. I wanted everyone working on this project to be using the same basic figures derived by the same method.

On receipt of these instructions Mr. Barnes prepared the attached memorandum to set down the best available information for this study. If in the future new information becomes available on the ore reserves, Mr. Barnes will issue a memorandum outlining any changes. This memo will be distributed by this office to all interested persons.

Very truly yours,

Original Signed By
D. R. JAMESON

D. R. JAMESON
Superintendent

DRJ:df

Encls.

cc: RSHerde w/encl.
AJKroha "
GWBossard "
WLKurtz "
BLRickman "
RABarnes "

AMERICAN SMELTING AND REFINING COMPANY
SILVER BELL UNIT
Silver Bell, Arizona

February 9, 1972

MEMORANDUM TO: Mr. D. R. JAMESON, Superintendent

The following figures were phoned to Don Crowell today, and I thought they may be of interest to you for reference purposes.

1). Reserve tons and grade of non-sulfide ore in East Extension #2 = 10,466,020 @ 0.86/0.70%.

2). Reserve tons and grade of non-sulfide ore inside and outside pit = 12,804,100 @ 0.85/0.68%.

3). Tons and grade of non-sulfide ore mined to date = 7,263,510 @ 0.75/0.56% (This tonnage includes 489,450 tons @ 0.72/0.43% mined from the main pit area and dumped on No. 9 dump.)

4). Reserve tons and grade of non-sulfide ore remaining to be mined inside pit = 4,691,730 @ 0.89/0.69%.

5). Average calcite ($CaCO_3$) content in (1) above = 23.7%.

6). Average calcite ($CaCO_3$) content in (2) above = 21.5%.

R. A. Barnes
R. A. Barnes

RAB:jca

JHC

W.L.K.

FEB 9 1972

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
February 7, 1972

Memorandum to Mr. R.B. Meen

SILVER BELL UNIT
Acid Leach of East El Tiro
Sedimentary Oxide Ores

This memorandum will list the major points discussed at a meeting in your office on February 4, 1972 regarding the feasibility of acid leaching the East El Tiro Sedimentary Oxide Ores. The following people were in attendance:

R.B. Meen
R.S. Herde
A.J. Kroha
G.W. Bossard
W.L. Kurtz
F.T. Graybeal
D.E. Crowell

General

A study will be made to determine the feasibility of acid leaching the East El Tiro Sedimentary Oxide Ores in order to extract their contained copper and at the same time consume excess acid produced by the Hayden acid plant. This ore body consists of oxide capping which must be stripped to expose sulfide ore and is the ore body which was studied extensively from 1964 through 1966 with regard to the feasibility of ammonia leaching.

Ore Reserve

Current estimates of the ore reserves are as follows:

Category	Tonnage	Grade - % Total Cu/Oxide Cu
Ore already mined and placed in No. 10 Dump	6,500,000	.75/.56
Ore in place which must be stripped	4,840,000	.88/.69
Total	11,340,000	.805/.615

A cut off grade of .4% total copper was used for the above calculations.

In addition to the above ore, the exploration department estimates that there is some 2,250,000 tons of sedimentary oxide ore which need not be stripped. The grade of this ore will be checked but it is estimated to average about the same as the stripped material.

Metallurgy

There has been some preliminary test work done regarding the acid leaching of this ore. Information is contained in the reports in attachment A. In addition, the Minerals Beneficiation Department will work with the Silver Bell metallurgical staff to determine if any other pertinent information is on file at Silver Bell.

Work done to date has yielded the following preliminary information:

1.) One percent Co_2 content in the ore is equivalent to an acid consumption of 55 lbs. per ton of ore treated.

2.) The Co_2 content of the ore varies widely but averages about 8 percent. This will result in an average acid consumption of 440 lbs. of acid per ton of ore treated.

3.) Copper recovery is estimated to be between 70 and 80 percent depending on ore type and leaching method.

There has been very little test work done regarding a flow sheet for acid leaching this ore. This testwork will have to be done before any meaningful economic analysis of the project can be accomplished.

Two possible flowsheets are:

1.) Agitation leaching followed by counter current decantation and 2.) Vat leaching. Both flowsheets have serious disadvantages: Counter current decantation may prove to be difficult and costly because of settling problems and vat leaching may be impossible because of plugging by precipitated calcium sulphate.

Acid Supply

Mr. A. Kroha estimates that there may be as much as 750 tons per day of excess acid available at the Hayden acid plant by the end of 1974 or middle of 1975. The cost of this acid, delivered to Silver Bell, is indeterminate at this time. Preliminary economic studies of this project will use a range of delivered acid costs from 0 to 8 dollars per ton.

Future Work

1.) Test work must be done at Silver Bell to establish the basic flow sheet and operating costs.

2.) The Minerals Beneficiation Department will develop a preliminary feasibility study based on information presently known plus certain assumptions.

3.) The Exploration Department together with the Minerals Beneficiation Department will survey the area for possible tailing dam sites.

4.) The Exploration Department will investigate the possibility of additional acid leachable ore in the vicinity.

D.E. Crowell

D.E. Crowell
Milling Engineer

DEC:kmd
Attachment
cc: RSHerde
AJKroha
GWBossard
WLKurtz
FTGraybeal
File/S.B. Ammonia leach-acid
DRJameson
BLRickman
Mr. Lightner

ATTACHMENT - A

1.) Silver Bell metallurgy report No. 64-63, 11-27-64; "The Possibility of Acid Leach of El Tiro East Extension Sedimentary Non-Sulfide Copper Ores."

2.) Silver Bell metallurgy report No. 64-72, 1-8-65; "Laboratory Tests To Determine Amenability of Selected El Tiro East Extension Sedimentary Non-Sulfide Copper Ores To Acid Leach."

3.) Silver Bell metallurgy report from T.D. Henderson to B.L. Rickman of 4-8-71 entitled "Acid Agitation Leaching Tests of East El Tiro Ore Composite."

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

J. H. C.

January 12, 1972

JAN 12 1972

Mr. R. B. Meen
Building

Silver Bell District
Pima County, Arizona

Dear Sir:

Enclosed is a copy of my letter to Mr. Collins recommending a thorough study of the "greater" Silver Bell district. Both Mr. Collins and Mr. Snedden have given their approval for this work. Mr. Snedden requires that the Silver Bell geologist not neglect his normal duties to help the Southwestern Exploration Division and, further, that the Exploration Division will inform Mr. Jameson whenever they will be working on the Silver Bell Unit's ground.

I am assigning Mr. Graybeal to conduct this study and I am sure you, Mr. Jameson and Mr. Cameron will help him in any way you can. Because of the need to find outlets for the acid produced at Hayden, Mr. Graybeal's immediate attention will be placed on the search for and development of oxide copper reserves.

Mr. Graybeal will plan to start work in the Silver Bell District immediately.

Very truly yours,

W. L. Kurtz

W. L. Kurtz

WLK:lad
Enc.

cc: JJCollins - w/o enc.
TASnedden - w/o enc.
JHCourtright - w/o enc.
DRJameson - w/enc.
FTGraybeal - w/enc.
JWCameron - w/enc.

J. H. C.

DEC 23 1971

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

December 20, 1971

Mr. J. J. Collins
Director of Exploration
New York Office

Silver Bell District
Pima County, Arizona

Dear Sir:

For sometime now I have considered that a thorough geological study of the Silver Bell District should be conducted by the Southwestern Exploration Division. For this study I would consider the Silver Bell District to mean a large area surrounding Silver Bell and not just the known, exposed alteration zone.

The purpose of this study is to locate copper targets both within and outside of Asarco's ground. The work within the main district would be coordinated with the Silver Bell Unit and, hopefully, the Silver Bell geologist will have time to aid in this study.

This work would utilize all existing information (geology, drilling, assays, geochemistry, geophysics) coupled with the appropriate field and laboratory work. This in-depth study will point up not only residual targets within the main district, but also new possibilities outside of the main district. The study will be concerned not only with near-surface targets, but also possibilities at depth. Though testing of the deeper targets may not be undertaken at this time, it is an integral part of any thorough study of a major mining district. An important part of this study will be the endeavor to locate oxide copper reserves. As you recall, in our discussion of oxide copper deposits earlier this month, the Silver Bell District was thought to hold one of the best potentials available to Asarco.

An important outgrowth of this study should be a better understanding of the copper mineralization at Silver Bell, its regional setting, and its similarities and dissimilarities to the Lowell-Guilbert model. The information gained in this study should greatly aid in our continued exploration for porphyry coppers in the southwest.

With your approval, I should like to appoint one of the Division's geologists to this interesting and difficult assignment of a thorough, intensive study of the "greater" Silver Bell District. Since the work will involve a study of the records of the Silver Bell Unit, will you please obtain Mr. Snedden's permission for us to have access to the property and pertinent records.

W. L. Kurtz

W. L. Kurtz

WLK:lad

cc: JHCourtright

— open pit transport? and water!

9-22-71

~~J Lord — G Sthatis —~~
~~Rutile — Panamint — Calif —~~
~~Earl F Fox — 213 370 5338 — L~~
~~4714 Maricopa St Torrance 90503~~
~~hard rock — mica schist~~
~~Du Pont looking after mining congress~~

Silver Bell — (Bob Barnes) 1971
at 45¢ Cu — .44% cu — break even
at 80% mill rec (no stripping)
Total cost $2.46 per ton — (allows 10¢/lb smelt etc.)
at 50¢ Cu 7 lb x 40¢ = $2.80 = 34¢ (strip 1.5 tons)
— at 50¢ — .44% cu — can strip 64' O.V. (?)

File { Silver Bell

Silver Bell, General
JHC Sec'y File

June 18, 1971

Mr. Robert C. Edmiston
2851 N. Magnolia Ave.
Tucson, Arizona 85712

Silver Bell
Thermal Gradients

Dear Bob:

Please accept my apology for the delay in replying to your letter of March 30. I have some plausible excuses, but won't bore you with them at this time.

I'm glad to learn that you have completed the field work. It was a worthwhile line of investigation, even though the results do not indicate this technique to be particularly useful in exploration (at least, at Silver Bell).

I don't believe it will be necessary to submit a draft of your thesis to this office, however you should obtain Company approval before publishing the results.

Yours very truly,

J. H. Courtright

JHC/jmm

cc: WLKurtz

RECEIVED
MAR 31 1971
EXPLORATION DEPT.

W.E.S.
MAY 28 1971

J. H. C.
APR 1 1971

2851 N. Magnolia Ave.
Tucson, Arizona 85712

March 30, 1971

WES WKK
cull

Mr. J. H. Courtright
Chief Geologist, ASARCO
1150 N. 7th Ave.
Tucson, Arizona

Dear Mr. Courtright:

The field work on my thesis concerning thermal gradients at Silver Bell has been completed and I wish to thank you for having extended permission to me to carry out this study at Silver Bell.

A total of 30 holes have been logged in the areas east and west of Oxide Pit and northwest of El Tiro Pit, including Daisy Hill. One of the conclusions I have reached is that the oxidation of disseminated sulfides may cause surface temperature anomallies of not more than one degree centigrade. This is barely within the resolution of present infrared imagers and much less than temperature fluctuations due to topographic or seasonal effects.

Enclosed is an example of the illustrations I plan to use in my thesis to present this data. In addition the thesis will contain topographic maps showing the hole locations and possibly some geologic cross sections. At the present time I am not planning on including surface geologic maps.

No quantitative estimate of copper mineralization will be made either in terms of tonnage or grade except for order-of-magnitude descriptions of sulfide ratios. However, the distribution of the sulfides in the areas studied in terms of the total sulfide content is important to the thesis.

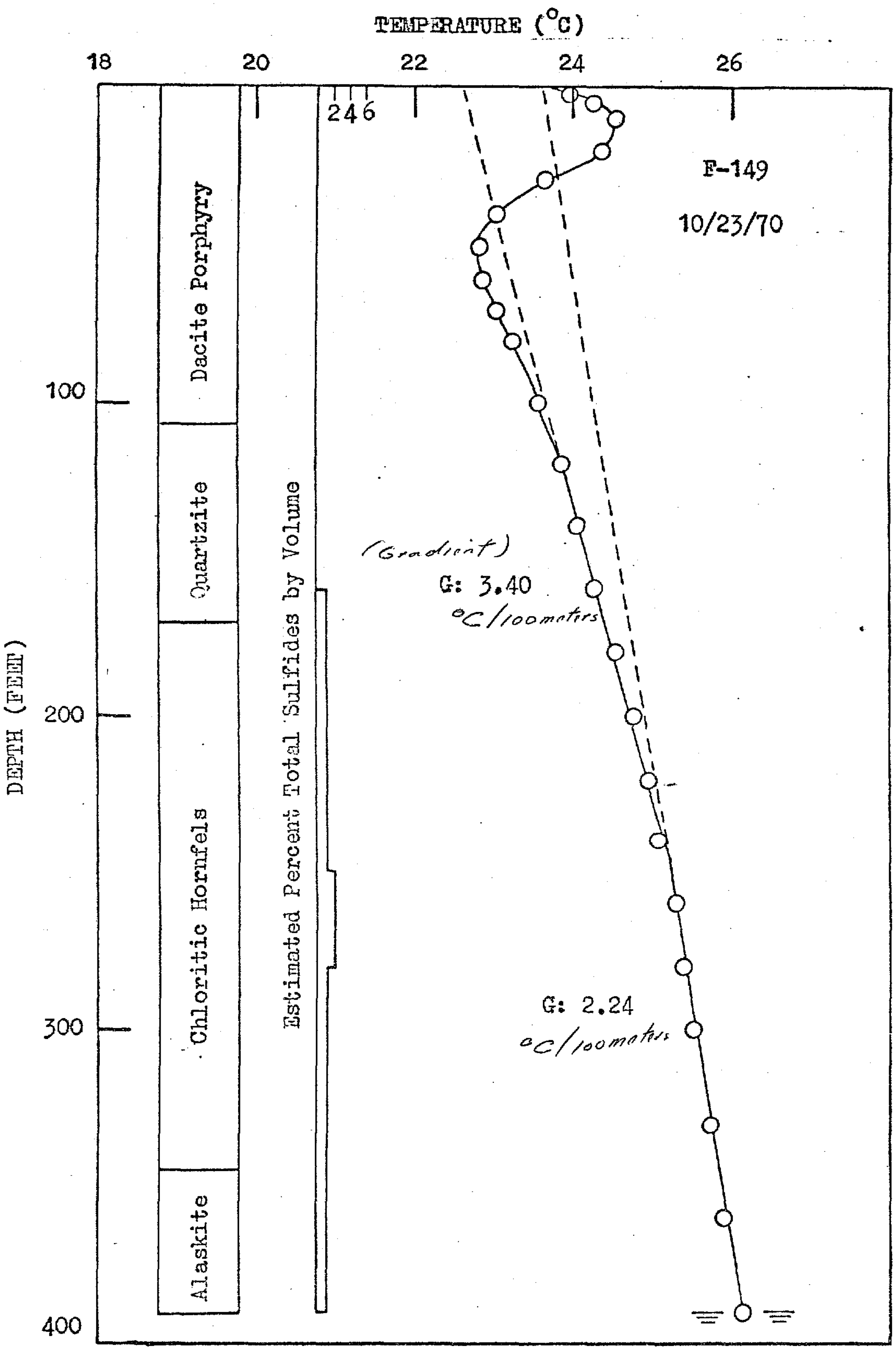
A complete rough draft of the thesis can be made available to ASARCO prior to the final draft being submitted to the University if you so desire. I hope to eventually publish some of the results in a condensed form.

Sincerely yours,

Bob Edmiston

Robert C. Edmiston

RECEIVED
MAR 31 1971
EXPLORATION DEPT.



Silver Bell, Arizona
& Michiquilay, Peru
Lib. files

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

March 1, 1971

TO: S. A. Anzalone

Dear Sal:

Enclosed are geochem reports on Silver Bell and Michi.

Moly values in the leached capping at Michi reflect quite well the zone of better copper values in the sulphide zone. The copper anomaly is less well defined. There's essentially no oxide or silicate Cu in the surrounding less altered to fresh rocks at Michi --- as is the case in many porphyry copper deposits.

Moly values in the capping at Silver Bell also show correspondence with the better copper sulphide occurrences; however, due to the stripping, only a few areas of capping were left to sample. There's more data (graphs, etc.) on Silver Bell, but it wasn't very well summarized, so I left it out and had a new map put together (enclosed). It doesn't show very well the erratic nature of the copper values, but numerous highs occur outside the zone of alteration.

J. H. Courtright

JHC/jmm

File Geochemistry, Ariz
Silver Bell Sacaton

GEOPHYSICAL DIVISION

3422 SOUTH 700 WEST
SALT LAKE CITY, UTAH 84119

RECEIVED
JAN 28 1971
EXPLORATION DEPT.

January 27, 1971

J. H. C.
JAN 28 1971

MEMORANDUM to R. J. LACY:

VISIT TO THE TUCSON OFFICE AND
SACATON AREA - JANUARY 20-21, 1971

January 20, 1971, was spent in the Tucson Office briefly discussing geochemical aspects of several projects with Messrs. W. Farley, J. King and N. Whaley. January 21 Mr. Whaley visited the Sacaton district with Mr. K. H. Nation and myself.

Proposed Geochemical Orientation Study of Groundwater, Sacaton Area:

Information obtained by Mr. Whaley from the Agricultural Department, University of Arizona, indicates that the proposed geochemical study of groundwater in the Sacaton--Casa Grande area cannot be attempted until Spring or Summer when irrigation becomes widespread. I plan to initiate the study as soon as the conditions are satisfactory.

The morning of January 21, Mr. Whaley visited the Sacaton area with Mr. Nation and myself in order to instruct us in the general nature of the irrigation pumps, etc., so that we might be better aware of the nature of the water samples we propose to collect.

Mesquite Study, Sacaton Area:

Mr. Nation has begun a one week to ten day mesquite sampling program over the Sacaton--Casa Grande area. This study is designed to determine the extent to which trace element, in particular Mo, concentrations in Mesquite reflect the presence of anomalous groundwater and, indirectly the presence of the Sacaton orebody. This factor is particularly important in other parts of this district (e.g. parts of Stanfield anomaly area) where little or no sampling access to groundwater is available.

Mercury Study, Sacaton Orebody:

As part of our continuing program of investigation of Hg distribution in and around porphyry deposits the afternoon of January 21 was spent obtaining representative samples or core from drill holes along the 550 N. section line across the Sacaton deposit.

Mercury Study, Silver Bell:

Mr. J. King, who was recently engaged in a geological study of the Silver Bell area, was interested to learn of the anomalous Hg concentrations detected in two un-mineralized rock samples recently collected by myself from locations some distance from the known orebodies and analyzed in our study of Hg distribution in and around this and other deposits. This anomalous situation appears to provide supporting evidence for certain hypotheses he has developed of local ore distribution. It could conceivably be indicative of primary dispersion halos related to mineralization at depth.

As there is a slight possibility that my original samples, which were taken from the vicinity of the mine haulage road, could have been contaminated, Mr. King has agreed to collect a few additional samples from the same general locality. If these new samples prove to carry anomalous Hg concentrations a systematic rock or soil sampling program in the vicinity of the Silver Bell orebodies will probably be warranted.

Picacho Area Groundwater Data:

Mr. W. Farley has previously sampled groundwater from wells in the vicinity of Picacho, Pinal County, Arizona, in an attempt to evaluate the large magnetic anomaly occurring in the area. On the basis of data obtained elsewhere in the region the Mo content of the samples would be provisionally classified as possibly or probably anomalous. However, this apparently anomalous groundwater could conceivably be related to known mineralization (i.e. Silver Bell--some 10 - 15 miles distant). Of possibly greater significance is the local occurrence, particularly in the immediate vicinity of the magnetic anomaly, of apparently anomalous Cu concentrations. These certainly merit additional attention as the Cu would not be expected to have moved far from source (be it in bedrock or in the valley fill) because of prevailing groundwater conditions. It is planned to undertake further work in this area when the next irrigating season begins. Apart from resampling of groundwater, pH measurements will be made. The presence of acidic groundwater in the immediate vicinity of the magnetic anomaly could be indicative of proximity to weathering sulphides.

L. D. James.

L. D. JAMES

LDJ:db

cc: J.J.Collins
J.H.Courtright
W.E.Saegart

INTER OFFICE MEMO

file: Silver Bell

To J. W Camero JHC - Keep **Date** 10/20/70

From W. E. SAEGART

J. H. C.

Subject Your September monthly report.

DEC 16 1970

MESSAGE I note with interest - assays as high as 0.83 % Cu in "Protore" below base of enrichment in D-316. Would appreciate copy of map showing location of these holes. Also interested in average Cu grade in interval 150' - 200' (protore) in D-316

cc: JJS
DRJ

Signed

REPLY D-316 averaged 0.38 % Cu from 153.7' to 190.0'. Also noted that the lower 30' in D-313 had primary cp with the last interval assaying 1.15/Mil % Cu. Also 518 carried 115' of primary cp below enrichment, with fair Cu assays - (last int. 41/.61 % Cu). Attached find 2 plan maps of NSB drill holes, one color coded for ore intervals with 0.32% Cu cutoff.

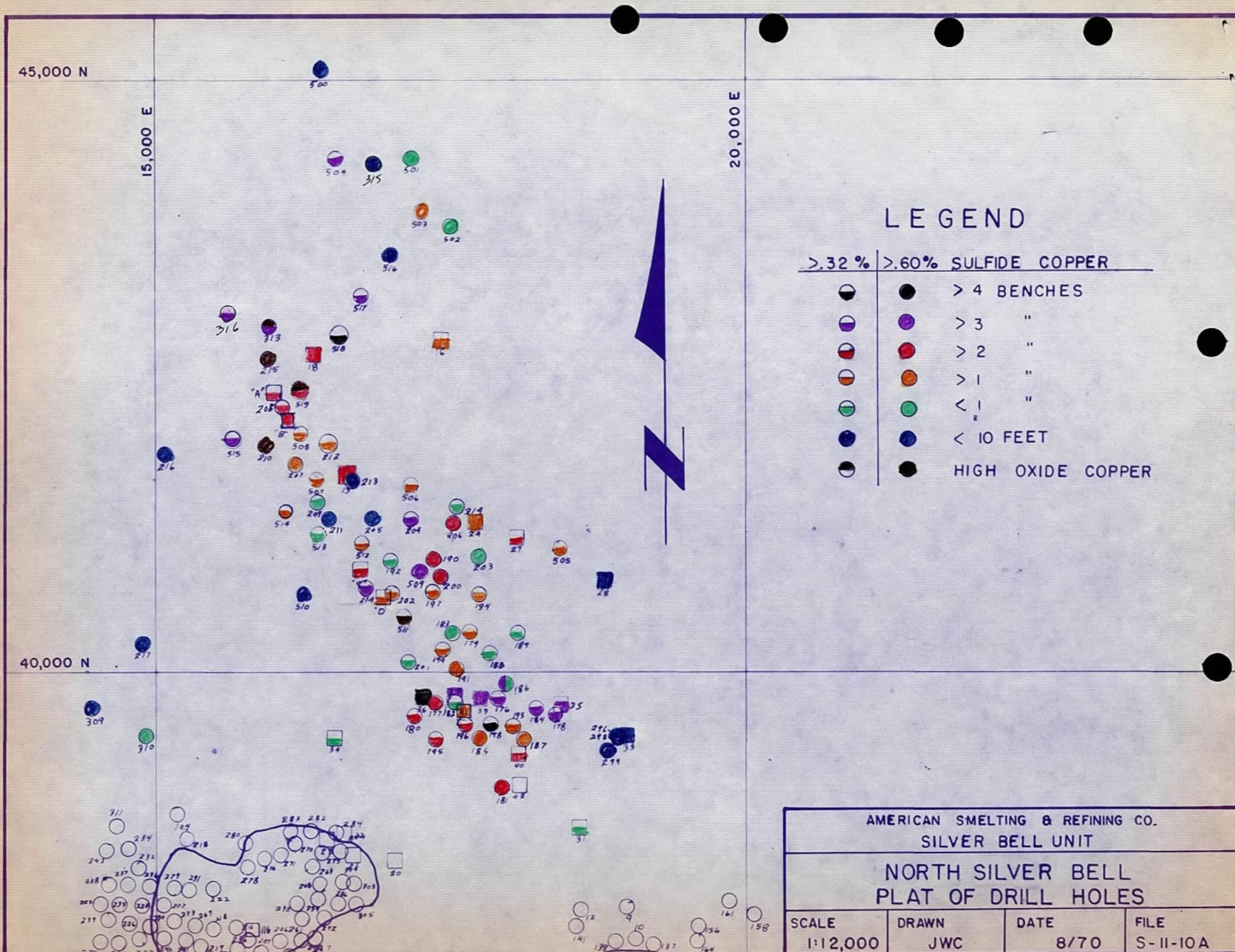
Date 10/23/70 **Signed** J. W. Cameron

SEND COPIES 1 AND 3 WITH CARBON INTACT - RETURN COPY 3 WITH YOUR REPLY

Form 2644

maybe some ~~possibility~~ possibility of low grade primary ore for future consideration

W-E-S


45,000 N
40,000 N
15,000 E
20,000 E
N
LEGEND
>.32 % | >.60% SULFIDE COPPER
> 4 BENCHES
> 3 "
> 2 "
> 1 "
< 1 "
< 10 FEET
HIGH OXIDE COPPER
AMERICAN SMELTING & REFINING CO.
SILVER BELL UNIT
NORTH SILVER BELL
PLAT OF DRILL HOLES
SCALE 1:12,000
DRAWN JWC
DATE 8/70
FILE S-11-10A

J. H. Courtright

GEOPHYSICAL DIVISION
3422 South 700 West
SALT LAKE CITY, UTAH 84119

J. H. C.
AUG 5 - 1970

July 17, 1970

MEMORANDUM TO R. J. LACY:

AEROMAGNETIC INDICATIONS
SILVER BELL NORTH, ARIZONA

In the past I have discussed, orally, some implications of the magnetic picture in the subject area; at this time I will take the opportunity to put my observations into writing.

The high level magnetic survey over the Silver Bell district shows a dominant positive magnetic anomaly, trending east-west, which correlates with the occurrence of Precambrian granite. The Silver Bell-El Tiro mineralization lies at the south flank of this granite.

Recent broad-scale studies of aeromagnetics in the Southwest, by Company geophysicists, have shown that the flanks of the granite are particularly favorable for the occurrence of "porphyry" intrusives.

Attached is a magnetic contour map of the Silver Bell district which includes a generalized interpretation of geology as deduced therefrom. An examination of the magnetic contours shows a moderate degree of symmetry in the contour pattern across a magnetic axis lying east-west along the Precambrian granite. Such an indication of symmetry immediately brings to mind the question of mineral potential on the north side of the granite.

I would propose that the mineral potential for this north area is enhanced for the following reasons:

1. The area encloses a contact of the Precambrian granite.

2. The area lies in close proximity to Silver Bell mineralization.

3. A north-south basement fault is indicated which might structurally connect the subject area with the Silver Bell-El Tiro zone.

4. Magnetic variations of moderate amplitude exist in the area which

could reasonably represent Tertiary intrusive conditions.

For the interpretation of intrusive geology on the enclosed map I have correlated magnetic features with observed geology where possible and have then extrapolated the geology into covered ground in accordance with the associated magnetic pattern. Needless to say, any magnetic map can have a multiplicity of interpretations.

Low-level aeromagnetics, gravity, detail geologic mapping, and I. P. would represent a logical sequence of activity in continuing exploration of the north area. However, having presented the above case, I would leave the weighting of this evidence to the regional supervisor. He could pursue this work according to the priority his judgment gives this work relative to other Southwest projects.

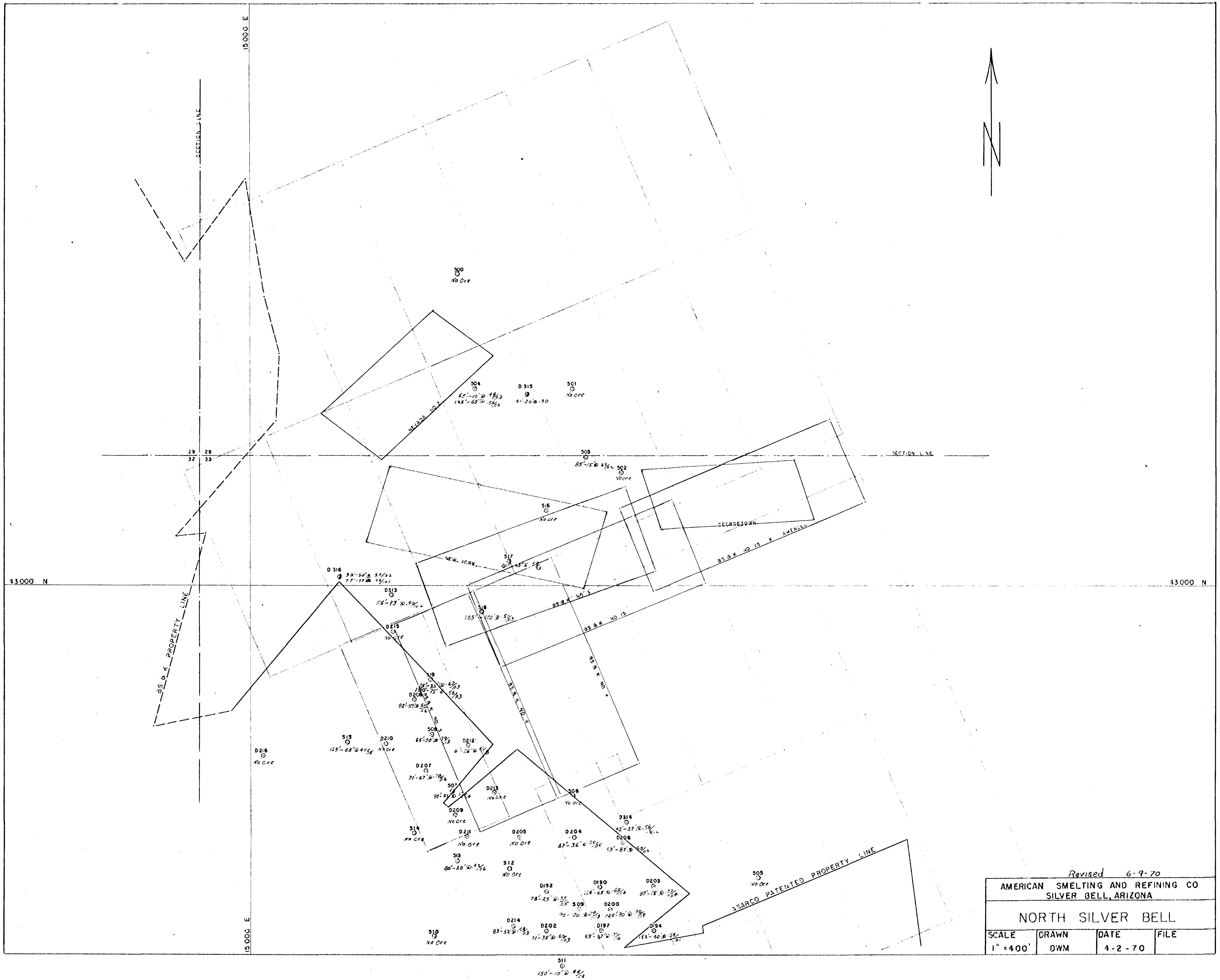
I would, though, recommend the flying of a standard (low level) aeromagnetic survey over the area, to supplement our general study of magnetic features of the porphyry copper province.

C. K. Moss

C. K. MOSS

CKM:am
Attch.

cc: J. J. Collins, w/enc.
J. H. Courtright "
W. E. Saegart "
W. G. Farley "



Revised 6-9-70
AMERICAN SMELTING AND REFINING CO
SILVER BELL, ARIZONA
NORTH SILVER BELL
SCALE 1" = 400'
DRAWN DWM
DATE 4-2-70
FILE
15000 E
43000 N
SECTION LINE
29 28
32 33
BS & K PROPERTY LINE
ASARCO PATENTED PROPERTY LINE
NEVADA NO 2
NEW YORK
GEORGETOWN
BS & K NO 15 & AMENDED
BS & K NO 15
BS & K NO 4
500
No Ore
504
D 315
501
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503
502
No ore
516
No ore
517
D 316
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518
D215
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D210
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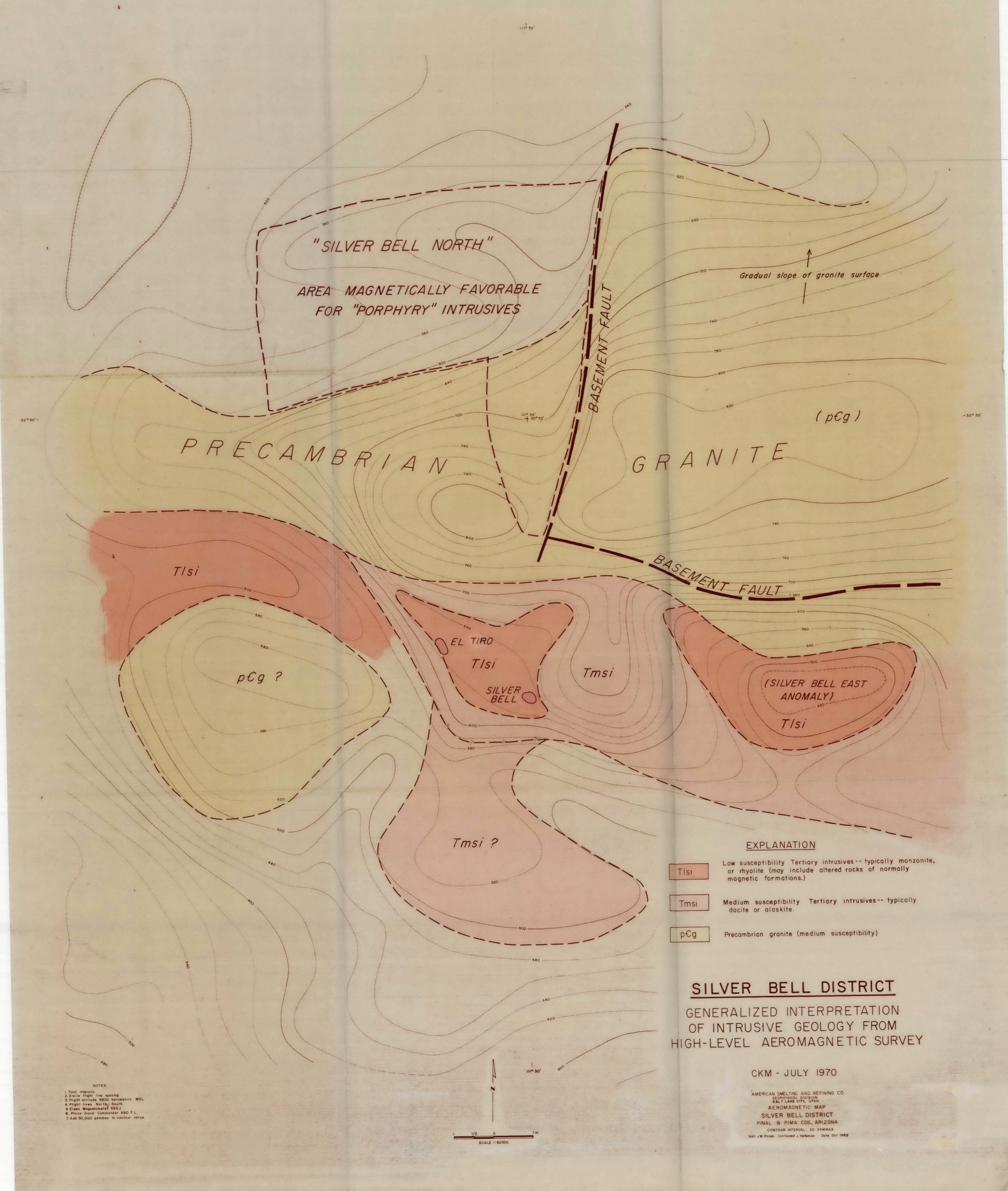
"SILVER BELL NORTH"
AREA MAGNETICALLY FAVORABLE FOR "PORPHYRY" INTRUSIVES
Gradual slope of granite surface
BASEMENT FAULT
PRECAMBRIAN GRANITE
(p€g)
BASEMENT FAULT
Tlsi
EL TIRO
Tlsi
SILVER BELL
p€g ?
Tmsi
(SILVER BELL EAST ANOMALY)
Tlsi
Tmsi ?
EXPLANATION
Tlsi Low susceptibility Tertiary intrusives -- typically monzonite, or rhyolite (may include altered rocks of normally magnetic formations.)
Tmsi Medium susceptibility Tertiary intrusives -- typically dacite or alaskite.
p€g Precambrian granite (medium susceptibility)
SILVER BELL DISTRICT
GENERALIZED INTERPRETATION OF INTRUSIVE GEOLOGY FROM HIGH-LEVEL AEROMAGNETIC SURVEY
CKM - JULY 1970
AMERICAN SMELTING AND REFINING CO.
GEOPHYSICAL DIVISION
SALT LAKE CITY, UTAH
AEROMAGNETIC MAP
SILVER BELL DISTRICT
PINAL & PIMA COS., ARIZONA
CONTOUR INTERVAL: 20 GAMMAS
Inst. J.M. Panek - Contoured J. Hafeman Date Oct 1969
NOTES:
1. Total intensity.
2. 2 mile flight line spacing.
3. Flight altitude 6800 barometric MSL.
4. Flight lines North - South.
5. Elsec Magnetometer 592 J.
6. Plane: Grand Commander 680 F.L.
7. Add 50,000 gammas to contour value.
SCALE 1:62500