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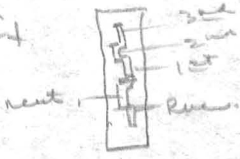
Silver Bell trip
6/4/52

Euclid twin engined trucks

700 hrs before replacement.

175-240 HP each.
cost $50,000, 33 TONS, 10 wheels
wheels drift on turns with high tire wear.
GM diesels, one equiped with Cummins, possibly little slower speed than GMs. About same fuel economy.
Very simple to drive.
Two torque converters drive 1st axle, direct drive from 1st axle to 2nd axle. No clutch lever for only shift



torque converters. Power steering. Emergency brake disconnected, Air brake on foot pedal, and wheel, and fuel pedal. Ran from one motor, 10 wheels. Runs smoothly, comfortably - easy to reach without leaning out as reported for Dart trucks.

(Crocker says new Cananea Dart trucks cost $43000
one he built $34,000

SPRING MEETING
OPEN PIT DIVISION, ARIZONA SECTION A.I.M.E.
D. R. Purvis, Chairman
Silver Bell, Arizona
April 23, 1956

PROGRAM

Morning and Afternoon

9:00 A.M. Registration

10:00 A.M. Technical Session

"Silver Bell Pit Development"
By: J. J. Sense, A.S.&R.Co.

"Asphalt Mixed Surface Mat for Heavy Duty Haulage Road"
By: Luther M. Krupp, Isbell Const. Co.

"Twin Power Earth Moving Equipment"
By: Alan S. McClimon, Euclid Division, G.M.C.

"Haulage Economics"
By: W. G. Gerow, Cummins Engine Co.

Film, "10 Days per Year"
Courtesy Euclid Division, G.M.C.

Film, "Cummins Race Car"
Courtesy Cummins Engine Co.

12:30 P.M. Stag Luncheon

2:00 P.M. Tour of Pits

Evening Program

6:00 P.M. to 7:00 P.M. Cocktails at El Conquistador Hotel in Tucson.

7:00 P.M. Dinner at El Conquistador Hotel

El Conquistador Hotel is located in the 3400 block of East Broadway, Tucson, Arizona

El Tiro 1/3 7500 T/day 2650 El. pit Tiro
OXIDE 2/3 2 mi. apart 27 Mill.
29% grade on Road.

24.5% floor 177,000,000
of first 197,000,000

OXIDE 100-200' thick under 100' waste

Tiro 100-300 thick, waste [illegible] 200

Iskull stripping 1951 - 53
Stearns Roger Mill
Utah Const. [illegible]

Ox {18.5 waste / 4.5 tons ore oxide pit}

Tiro {500,000 / 10,000,000 W.}

1 mi to waste disposal
0.4 mi " "

3 6 yd elect Bucyrus Erie
3 5 diesel

56° backslope
12 yrs. life
40' benches

32,000,000 mil. ton Reserve. 0.9% cu
waste ore
1.2 - 1

Sub grade $34,360/mi
Paving 14,
$49,202 Total

4 mi, Asphalt mix pavement.

$22,000 for 1 1/2 Section to El P.N.G. plant
22' road

samples / hr.
40'

300' ± shift in waste
factor in ore.

2830 Bench
2750

OX.
2900

561 1305 Silicated LS
Little Face, stain at 1284

341 791 qtzite 751 785 spotty

334 542 Dio

1,200,000
120,000
20,000
8,000,000

ROLAND B. MULCHAY
MAR. 2, 1954
AIME SPRING MEETING

STRUCTURE AND MINERALIZATION, SILVER BELL, ARIZONA

By

Kenyon Richard and J. H. Courtright, Geologists

AMERICAN SMELTING AND REFINING COMPANY

A paper to be presented at the annual meeting of
THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS
New York, February 17, 1954

ABSTRACT

Replacement-type ore bodies in tactite have accounted for the Silver Bell District's production of copper in the past. In the near future, substantial production will come from porphyry-type copper ores occurring in two deposits spaced two miles apart within a northwesterly trending zone of hydrothermal alteration several miles in length. This zone lies along a major regional fault which is believed to have formed initially in Paleozoic and Cretaceous sedimentary rocks, and subsequently to have been the locus of repeated Laramide igneous activity. Alaskite followed by dacite porphyry were intruded first. Then, after an erosional interval marked by basal conglomerate, a thick series of dacite flows and pyroclastics was deposited. Intrusions of small stocks of monzonite and related dikes were preceded and partly controlled by: (a) regenerative movement along the major structure and (b) development of cross-breaking fractures. Renewed development of cross-breaking joint systems along the main zone provided the principal control of ensuing hypogene mineralization. Post-mineral andesite dikes were emplaced parallel to the major structures. Lastly, enrichment by supergene chalcocite formed the two ore bodies.

Features considered significant: (a) The belt of alteration and copper mineralization coincides with the inferred position of the original major fault. (b) The systems of close-spaced parallel joints were most favorable to deposition of the primary chalcopyrite. (c) The intensity and extent of supergene enrichment are reflected by the quantity of limonite-after-chalcocite in outcrops. (d) The erosional interval between alaskite and monzonite may be a useful means in age-distinction of Cretaceous and Tertiary igneous rocks.

INTRODUCTION

Purpose:

At Silver Bell the mineralized zone and a number of structural features trend west-northwest. Yet, mineralization is controlled in detail by northeast, cross-trending fractures. The purpose of this paper is to present interpretations of these and other relationships.

Previous Work and Acknowledgments:

The first scientific study of the district was published in 1912 by C. A. Stewart (5). Considerable field and laboratory work has been done in more recent years by several groups and individuals, including the writers, all reporting privately to the American Smelting and Refining Company. Roland Blanchard conducted leached outcrop studies in a portion of the area. Harrison Schmitt with H. M. Kingsbury and L. P. Entwistle mapped structure and mineralization in the central part of the district. Paul F. Kerr studied the alteration features, and later published a comprehensive paper (3) on the district. Thomas Mitcham mapped structural features in the surrounding area. The writers have drawn considerably on unpublished data, particularly in compilation of the geologic map. The high quality and usefulness of the work of these men is gratefully acknowledged, but unfortunately it is not feasible to give specific individual credits.

Thanks are due the American Smelting and Refining Company for permission to give this paper.

Location:

Silver Bell is situated 35 airline miles northwest of Tucson, Arizona, in a small, rugged range rising above the extensive alluvial plains of this desert region. Its geographical relation to other porphyry copper deposits of the Southwest is shown on the inset map in the lower left corner of Plate 1. The climate is semi-arid. Altitudes range within 2000 and 4000 feet.

History:

Opening of the Boot Mine, later known as the Mammoth, in 1865 was the first event of note in the district's history. Oxidized copper ores containing minor silver-lead values were mined from replacement deposits in garnetized limestone and treated in local smelters. Copper production had approached 45 million pounds by 1909 when the disseminated copper possibilities in igneous rocks were recognized. Extensive churn drill exploration was carried out during the next three years and resulted in the partial delineation of two copper sulphide deposits, the Oxide and El Tiro. Although the then-submarginal tenor discouraged exploitation of these disseminated deposits, selective mining of ore bodies in the sedimentary rocks continued intermittently until 1930, providing a production total of about 100 million pounds of copper.

The American Smelting and Refining Company began exploratory and check drilling in 1948 and subsequently made plans for mining and milling the Oxide and El Tiro ore bodies at the rate of 7500 tons per day. Production will start during the second quarter of this year at a rate of about 18,000 tons of copper annually.

GENERAL GEOLOGY

Formations ranging in age from Pre-Cambrian to Recent are exposed in the Silver

Bell vicinity. The more erosion-resistant of these, Paleozoic limestone and Tertiary volcanics, predominate in the scattered peaks and ridges comprising the Silver Bell mountains. The porphyry copper deposits are located along the southwest flank of these mountains in hydrothermally altered igneous rocks. These are principally intrusives which cut Cretaceous and older sediments and are considered to be components of the Laramide Revolution.

For three-fourths of its length, the zone of alteration strikes west-northwest (Plate I). There now is no single structure which accounts for this alignment. Howevery, indirect evidence suggests that a fault representing a line of profound structural weakness existed in this position prior to the advent of Laramide intrusive activity. This line will hereinafter be referred to as the "major structure". It was obliterated by the Laramide intrusive bodies, but it affected a degree of control on their emplacement, as evidenced by their shapes and positions. The influence of fault structures on the shapes of intrusives in other porphyry copper districts has been noted by Butler and Wilson (2), and by others.

As shown on the inset map on Plate II, a fault of parallel trend and considerable displacement lies to the north. This fault is now marked by a line of small Laramide intrusive bodies. To the south is a third fault of large displacement. Evidence of its age in relation to the Laramide intrusions and mineralization is not recognized, but its conformance in strike with the other two major faults is significant. These three breaks establish a pronounced trend of regional faulting. They are high-angle, and the southerly one may be reverse. Stratigraphic separations on these faults are of the order of several thousand feet.

The local Paleozoic section is about 4000 feet thick. It is composed predominantly of limestone with a basal quartzite member. The Cretaceous section appears to exceed 5,000 feet. Conglomerates, red shales, and arkosic sandstones (the youngest) characterize the three principal members.

Intrusion of alaskite marked the beginning of Laramide igneous activity. It was emplaced as an elongate stock with one side closely conforming to the major structure line throughout a distance of nearly four miles. The alaskite was at one time regarded as a thrust block of pre-Cambrian rock (2); however, its intrusive relationship and consequent post-Paleozoic age has been established by inclusions of limestone found in outcrops north of El Tiro. It is believed also to be post-Cretaceous although conclusive evidence of this has not been found at Silver Bell.

The next event was the intrusion of a large stock of dacite porphyry into Paleozoic sediments and alaskite. The stock was some three miles in width and at least six miles in length in a northwesterly direction. It was sharply confined along its southwest side by the major structure line. A number of large pendants of moderately folded Paleozoic sediments occur within and along its southwest edge. Thus, the inferred, original major fault between Paleozoic and Cretaceous sediments became a contact between alaskite and Paleozoic sediments and then, a contact between dacite porphyry and alaskite.

Andesite porphyry may have been intruded later than the dacite porphyry, but relationships are not clear; it may be simply a facies of the latter.

The intrusive activity was at this stage interrupted by an interval of erosion. The erosion surface probably was rugged as there were local accumulations of coarse, angular conglomerate. Subsequently, a series of volcanic flows and pyroclastics several thousand feet in thickness was deposited. A similar unconformity has been recognized elsewhere in the Southwest, particularly in the Patagonia Mountains near the Flux mine, some 75 miles southeasterly. Here, as at Silver Bell, volcanics were deposited on an erosion surface cut in Cretaceous and older sediments which had been intruded by alaskite.

Though no evidence is offered which closely defines the age of this unconformity, and proper analysis of the problem is beyond the scope of this paper, it is interesting to speculate that it may mark the close of the Cretaceous Period and provide a distinction between Tertiary and Cretaceous igneous rocks within the Laramide Revolution.

Subsequent parallel faulting along the major structure line sliced the volcanics and Cretaceous sediments into horst and graben structures. These faults are remarkably persistent southeasterly, extending several miles beyond the map. It is not clear if they originally extended through the northwest part of the district; they may have terminated against the earlier east-west fault shown on the inset map on Plate II. The formation of these faults indicates at that time a still-existent, deep-seated zone of weakness along the major structure line.

Monzonite stocks and contemporaneous dikes were then emplaced along and near this line, obliterating portions of the faults described in the foregoing paragraph. The stocks are elongate parallel to the major structure line. The dikes are distributed along this line but trend across it, for the most part, with an average east-northeast strike. Systems of close-spaced, parallel fractures then developed. Like the dikes, these fractures are distributed along the major structure and strike across it. Alteration and sulphide mineralization then took place. The deposition of sulphides, particularly chalcopyrite, was controlled in detail by the cross-trending fractures. Although these were distributed along the major structure line as a narrow band, it is notable that throughout much of its length there are now no fault structures to account for this trend.

Post-sulphide dikes of andesite represent the last intrusive activity in the immediate district. Curiously, most of these dikes parallel the strike of the major structure, although it would seem that the cross-breaking fractures represented available lines of weakness. This serves to emphasize the major structure line as being a profound, deep-seated zone of weakness persisting through a long period of time.

Uplift and erosion of the region during late Tertiary or Quaternary time exposed the lean primary mineralization to processes of weathering and enrichment, resulting in the accumulation of the two chalcocite ore bodies.

Small plugs and flows of basaltic lava occur in the flats surrounding the Silver Bell range. These are later in age than the Gila conglomerate and mark one of the more recent events in the geologic history of the region.

STRUCTURAL CONTROL OF HYPOGENE MINERALIZATION

As in the majority of porphyry copper deposits, the principal primary sulphide minerals at Silver Bell are pyrite and chalcopyrite. Although occurring as disseminated grains, they are more abundant as narrow veins or seams which are usually near-vertical in attitude and persistently parallel. Varying in thickness from paper-thin to several inches and, in spacing, from inches to several feet, these thin sulphide sheets occur as groups of various sizes throughout the narrow, northwest-trending zone of hydrothermal alteration. (Due to the small scale, a single line in the pattern of "Mineralized Fissures" on Plate I usually represents a large number of parallel structures, rather than an individual.) In detail the average individual fissure appears as a thin quartz-sulphide seam encased by a rather uniform band of sericite. The fissures are predominantly oriented in the northeast quadrant; a small proportion strike northwest and a few are random. From a broad viewpoint there are, among these systems, or groups, no intersections of consequence. Within groups, changes in strike occur gradually and result in curving trends. As noted earlier, these groups of mineralized fissures are distributed along the major structure line, and it is assumed they were formed in response to deep-seated, uniform stress related to this line.

At least a few hundredths of one per cent copper is present nearly everywhere in the altered zone; better values occur where there are mineralized fissures; and the best values, where the fissures are close-spaced. The two comparatively large groups of these close-spaced structures coincide with the positions of the two ore bodies (Plate I). However, the actual structural, mineralogical, and lithological distinctions among these and other, smaller groups are minor, and the factors that controlled the position and size of these two groups are not clearly evident. The strong east-west fault which terminates in the Oxide area may have influenced the concentration of fracturing there, and at El Tiro the sharp bend in the alteration zone and the group of northeast-striking dikes likewise may indicate a cross-trending line of weakness that localized stresses. Nonetheless, the importance of these structural conditions is not clearly demonstrated, and no good evidence is found to explain the structural cause of the more intense fracturing which localized the two ore bodies in their present positions in preference to other locations along the major structure line.

Outside of the zone of alteration the dacite porphyry is finely fractured and jointed throughout most of its large exposed area. In sharp contrast to the systems of parallel fissures in the alteration zone, these breaks in the dacite porphyry are almost completely disoriented; parallelisms are rare and traceable for only a few inches or feet. They appear to be pre-mineral where they are found in the alteration zone in the westerly and southwesterly portions of the dacite porphyry. It would seem that in physical aspect this formation was exceptionally well prepared to be mineralized---perhaps better than the rocks of the ore zone proper. The fact that it was mineralized only to a minor degree may be accounted for by the absence of systematic fractures. That is, only the systems of parallel fractures were connected with the deep-seated source of mineralization, and the pervasive breaking of the dacite porphyry did not alone qualify it for mineralization.

Excepting the post-mineral andesite dikes, all igneous rocks within the narrow northwest-trending zone shown on Plate I are hydrothermally altered. Variations in the intensity or in the completeness of the process, have been subdivided by Kerr (2) into five stages. His analysis demonstrated, among other things, that the known ore bodies occur within the more strongly altered areas.

The area outlined on Plate I includes all degrees of alteration, but no differentiation is made It merely represents the areal extent of bleached-appearing, igneous rocks showing evidence in the leached outcrops of pre-existing disseminated sulphides---principally pyrite. The transition to relatively fresh rock is quite sharp in many places, particularly along the contact with sedimentary rocks and on the faults in the southeast portion. However, along most of the southwest margin the transition is gradational, and the limit is an arbitrary line.

Tactite, composed essentially of garnet, quartz and lime-silicate minerals, is confined to a narrow belt along the southwest margin of the limestone pendants, except in the vicinity of the Mammoth and Union mines where it has replaced the full width of the sedimentary block. It has been suggested by Stewart (1) that the dacite porphyry and monzonite are responsible for this "contact metamorphism". The areal distribution of this tactite is such that, if it were to be considered strictly as a contact phenomenon, the alaskite would be as related to it as the other intrusives. Without going into the problem in detail, it is worth noting that the tactite occurs along the major structure line in such a manner as to indicate a close genetic connection with it. Supporting evidence in the form of well-defined structural controls of individual pods of tactite is not recognized. An occasional mineralized fissure cuts the tactite in the Mammoth and Union deposits, although the primary chalcopyrite ore bodies have little obvious structural control. Elsewhere, fissures in igneous rocks terminate abruptly at tactite margins.

SUPERGENE ENRICHMENT

The two ore deposits consist of rudely tabular accumulations of chalcocite from one to two hundred feet in thickness. Lying beneath about one hundred feet of leached capping, they were formed by two- to threefold enrichment of the copper contained in the primary mineralization. Typical ore is composed of altered rock and sulphides in a ratio of about 10:1 by weight.

Most of the capping over the ore bodies contains less than one-tenth of one per cent copper as cuprite, or other oxidation products, mingled with the limonite. Occasionally, somewhat higher values occur where copper has been precipitated as silicates and carbonates by reactive gangue material present in less altered rock. Within the ore bodies, where alteration is strong and the gangue is non-reactive, the upper limit of the sulphide zone (or, the base of oxidation) appears on open-cut faces as a sharply defined, highly irregular line. Only rarely is there a transition zone of mixed sulphide and oxidized minerals. In general shape the base of oxidation conforms to modern topography, even though local relief exceeds 200 feet. The water table for the most part now is well below the chalcocite zone.

Some of the irregularities of the base of oxidation are caused by displacement on post-chalcocite faults, but most are due to variations in rock permeability. This is evidenced by the dense siliceous character of a few sulphide remnants occurring well up in the leached zone, and by leached indentations of the sulphide zone along some of the fissures.

It is significant that the base of oxidation shows general conformance to the topography, but that in detail it is a highly irregular, sharply defined "front". Its present shape may have been produced by modification of a pre-existing base---one which was established during relatively moist climatic periods of the past. Under such conditions the water table would have oscillated at uniformly shallow depths and thus would have served to limit the depth of oxidation, thereby determining the shape of its base to some extent. Otherwise, under conditions involving depression of the water table---principally those of dryer climates---it appears that the oxidation process proceeded in the vadose zone independent of the water table, and that it advanced downward on a sharply defined front whenever oxygen-charged meteoric water reached it.

Opinions vary as to the role of the water table in the deposition of chalcocite and as to the reason for the chalcocite's distribution through a considerable vertical range. At Silver Bell pyrite and, preferentially, chalcopyrite are only partially replaced by chalcocite immediately below the line at the base of oxidation as well as on down through the zone of enrichment. This condition appears to be an argument favoring the theory that chalcocite is deposited at or below the water table. That is, the dissolved copper on its downward course by-passed available chalcopyrite and pyrite until it reached the water table where it formed chalcocite. The partial replacement of primary sulphides by chalcocite and its vertical distribution, as now existing, may then be explained as originating through the numerous cyclic fluctuations of the water table position.

LEACHED OUTCROPS

In the formation of most disseminated chalcocite deposits the enrichment process takes place progressively---copper is repeatedly dissolved, carried downward and precipitated. It has been well established by Blanchard (1), Locke (4) and others that under these conditions "limonites" of certain colors and textures are left behind in the leached capping as evidence of the pre-existing chalcocite.

The Silver Bell district provides exceptionally good examples of this phenomenon, but limonites of chalcocite derivation are not confined to the outcrops over the ore bodies. They are widely dispersed through the zone of alteration. Proper interpretation of their significance in respect to ore possibilities rests mainly on quantitative rather than qualitative appraisal. Mapping of the Silver Bell outcrops on this basis provided a valuable guide in exploration drilling. Results have demonstrated conclusively that the pattern of relatively strong copper mineralization at depth is reflected in the outcrops by the distribution and abundance of diagnostic limonites.

It may be of interest at this point to mention the ancient excavations which are numerous in the outcrops of the mineralized zone at Silver Bell. There is evidence indicating they are several centuries old. These shallow open cuts invariably follow close-spaced, parallel fissures containing the dark maroon limonite-after-chalcocite. Since there are no precious metals or visible copper in these fissures, it is plausible to assume that this limonite with its particular hue was considered valuable in the past as a pigment, perhaps for pottery or war paint. Thus, in the history of leached outcrop investigations, it seems that some early Arizona Indian tribe deserves at least honorable mention.

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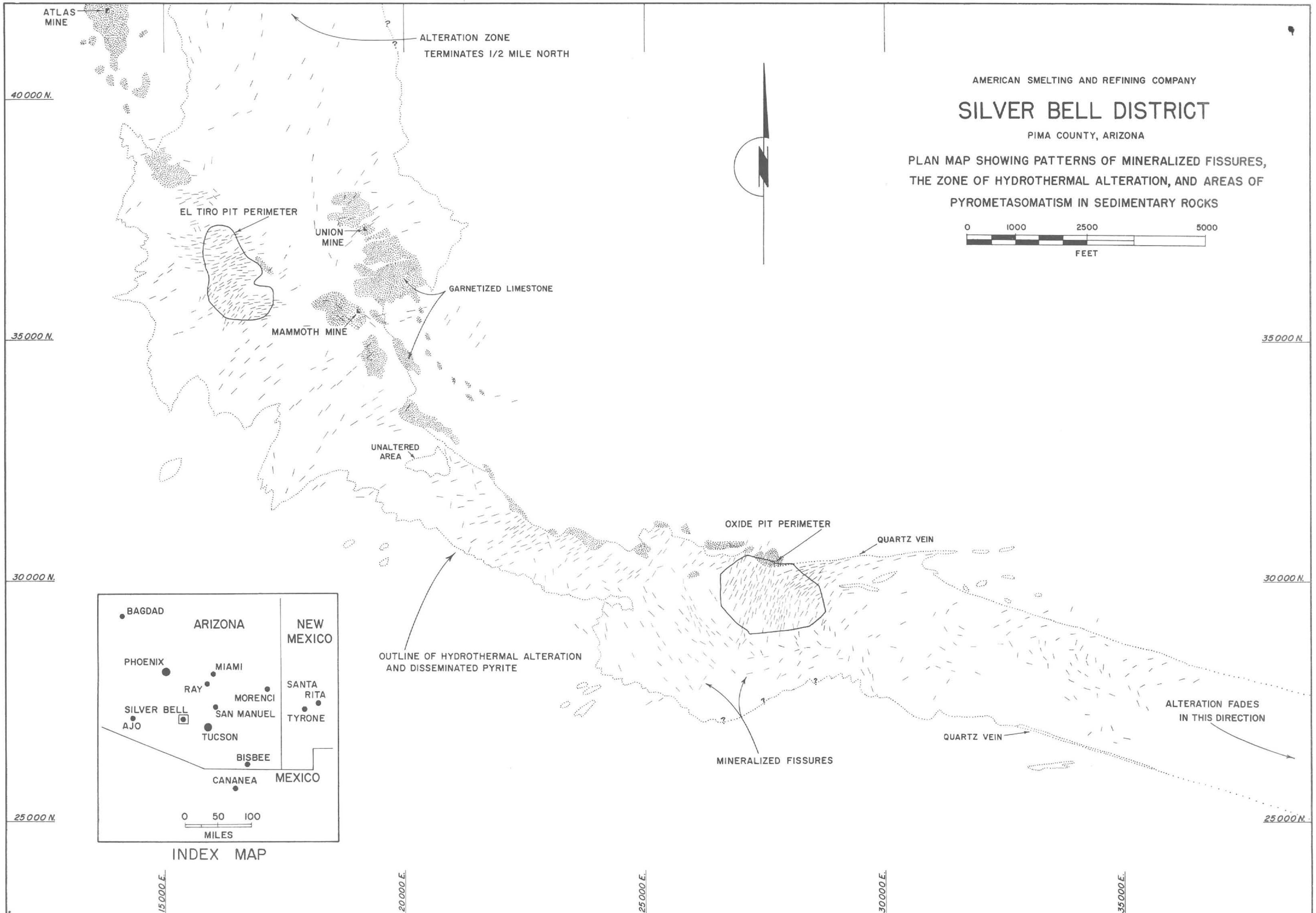
(1) Blanchard, Roland, "Interpretation of Leached Outcrops": Jour. Chem., Met. and Min. Soc. of S. Africa, May, 1939.

(2) Butler, B. S., and Wilson, E. D., "Clifton-Morenci District": Ariz. Bur. Mines, Bull. 145, p. 74, 1938.

(3) Kerr, Paul F., "Alteration Features at Silver Bell, Arizona": Geol. Soc. Am. Bull., Vol. 62, p. 457-480, 1951.

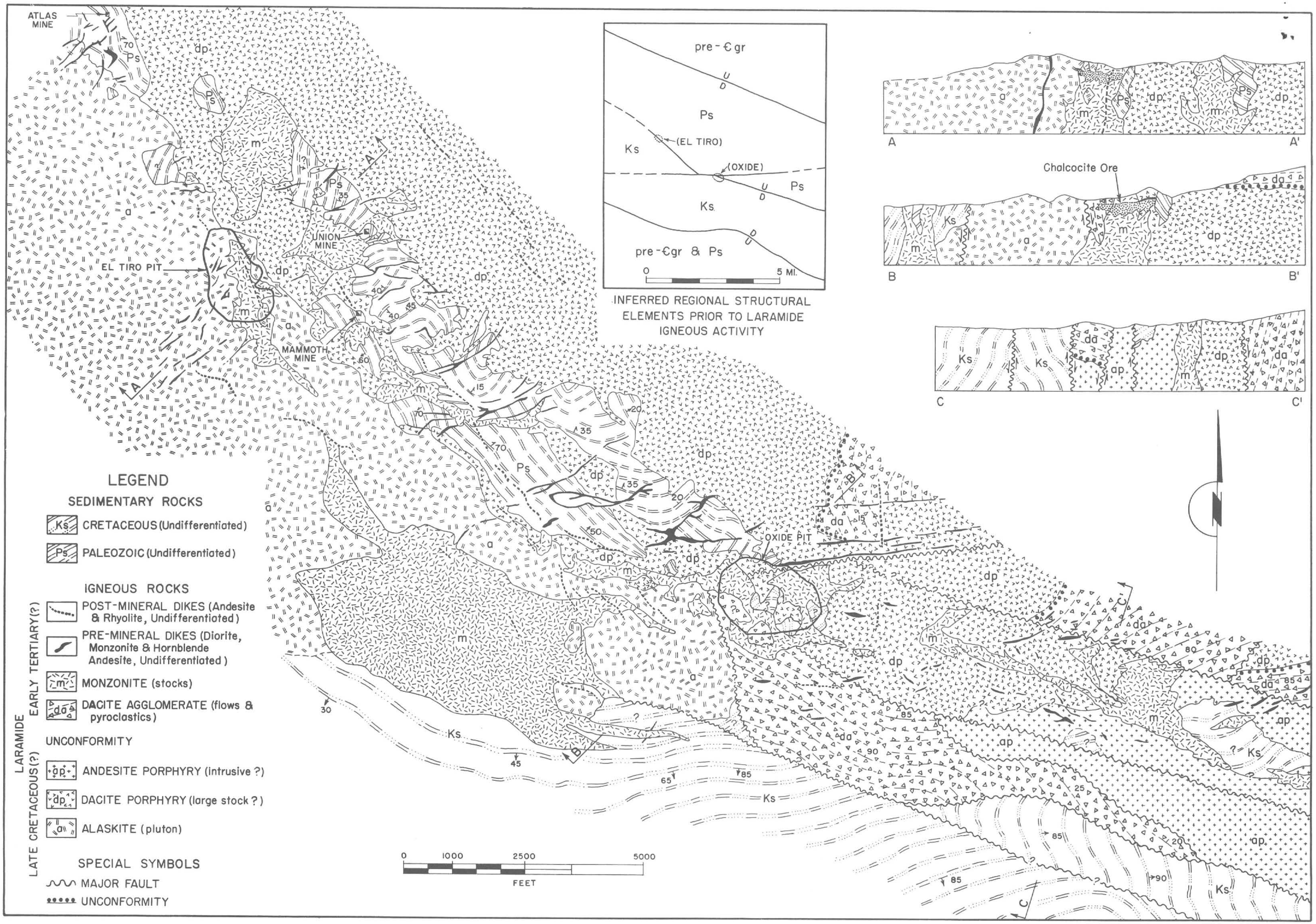
(4) Locke, Augustus, Leached Outcrops as Guides to Copper Ore: Williams and Wilkins, Baltimore, Md., 1926.

(5) Stewart, Charles A., "The Geology and Ore Deposits of the Silver Bell Mining Dist., Arizona". Am. Inst. Min. Met. Eng. Bull., Vol. 65, p. 455 - 506, 1912.



AMERICAN SMELTING AND REFINING COMPANY
SILVER BELL DISTRICT
PIMA COUNTY, ARIZONA
PLAN MAP SHOWING PATTERNS OF MINERALIZED FISSURES, THE ZONE OF HYDROTHERMAL ALTERATION, AND AREAS OF PYROMETASOMATISM IN SEDIMENTARY ROCKS
0 1000 2500 5000
FEET
ATLAS MINE
ALTERATION ZONE TERMINATES 1/2 MILE NORTH
40 000 N.
35 000 N.
30 000 N.
25 000 N.
EL TIRO PIT PERIMETER
UNION MINE
GARNETIZED LIMESTONE
MAMMOTH MINE
UNALTERED AREA
OXIDE PIT PERIMETER
QUARTZ VEIN
OUTLINE OF HYDROTHERMAL ALTERATION AND DISSEMINATED PYRITE
MINERALIZED FISSURES
QUARTZ VEIN
ALTERATION FADES IN THIS DIRECTION
BAGDAD
ARIZONA
NEW MEXICO
PHOENIX
MIAMI
RAY
MORENCI
SANTA RITA
SILVER BELL
SAN MANUEL
TYRONE
AJO
TUCSON
BISBEE
MEXICO
CANANEA
0 50 100
MILES
INDEX MAP
15000 E.
20000 E.
25000 E.
30000 E.
35000 E.

PLATE I



GEOLOGIC MAP, SILVER BELL DISTRICT, ARIZONA

PLATE II

W E I Corp

2,000,000

6/53 V loan 4,950,000

500,000 sh 428,221 outstand

614 Frelinghuysen Ave Newark 5 NJ

Roland B. Mulchay
Spring Meeting AIME Apr. 1956

Silver Bell Pit Development

By
J. J. Sense

American Smelting and Refining Company
Silver Bell, Arizona

SILVER BELL PIT DEVELOPMENT

The Silver Bell 7500-ton per day open pit operation of American Smelting and Refining Company is located about 40 miles northwest of Tucson, to the west of Avra Valley, at the southern end of the Silver Bell Mountains.

DISTRICT HISTORY:

Development on the Silver Bell copper deposits began in 1873 on the Mammoth Lode. In 1881, after construction of the Southern Pacific Railway through Tucson, the Huachuca Mining and Smelting Company began mining rich oxidized copper ore from the Mammoth, Old Boot and Blue Coat claims. In 1882, four different companies operated in the district but were soon discouraged by transportation problems and low metal prices.

In 1891, Silver Bell Mining Company built a smelter in Tucson and operated it intermittently. In 1902, the Imperial Copper Company obtained the Old Boot, Mammoth, and other claims, developed a sizable ore body and built a railroad from Red Rock to Silver Bell, which they completed in 1904. During this period, several companies were organized, including Oxide Copper Company, to develop the Young America Group and the Cleveland-Arizona Copper Company (later El Tiro Copper Company) to develop claims adjoining the Imperial and Indiana-Arizona Company. In 1915, American Smelting and Refining Company purchased the holdings of Imperial Copper Company and operated underground mines until 1919. In 1934, all machinery, equipment and buildings were moved out, and Arizona Southern Railway from Red Rock to Silver Bell was dismantled. In 1940, the present operator acquired the property of the Oxide Copper Company, which had drilled 76 holes, and outlined a disseminated copper deposit between 1909 and 1912, which, during those early days, was considered too low grade to be commercial.

During this same period, Imperial drilled 87 holes in the El Tiro area, second pit area of the present operation.

A number of estimates were made for opening up the property, but because of the relative low tonnage of the deposit, any possible program did not seem attractive.

In 1948, a camp was established to accommodate crews for check drilling and additional exploration work. This work further increased the reserves and made it possible to enter into an agreement in November, 1952, with Defense Material Procurement Agency. This agreement provided for complete financing by the Company and a floor price of 24-1/2 cents per pound of copper, subject to adjustment for increased operating costs, for 177 million pounds of the first 197 million pounds produced.

The unusual feature of the above history is that both of the present pit areas, the Oxide and the El Tiro, were recognized and extensively drilled some forty years before the present operation became a reality.

GEOLOGY:

All of the early mining in the Silver Bell district was in replacement type ore bodies. The present production is from porphyry-type ores occurring in two deposits known as the "Oxide" and "El Tiro" ore bodies. These bodies are spaced some two airline miles apart, with northwesterly trending zone of hydrothermal alteration several miles in length. Alaskite, dacite and monzonite porphyry, with minor andesite dikes parallel to the alteration zone, have been enriched by supergene chalcocite to form the two ore bodies.

The Oxide pit obtains its name from a claim in the district, not from the type of ore. The Oxide ore body is saucer-shaped, varying in thickness from 100 to 200 feet beneath 100 feet of leach capping. Dimensions are 1500 feet by 2100 feet.

The El Tiro ore body is elipsoid shaped, but very irregular in outline and cross-section. The ore is found beneath 100 feet to 300 feet of leach capping and varies in thickness from 100 feet to 300 feet. The dimensions of the El Tiro pit are 1300 feet by 2200 feet.

Additional details on geology can be obtained by referring to a paper titled "Structure and Mineralization, Silver Bell", by Kenyon Richard and J. H. Courtright, A.I.M.E., New York, February 1954.

WORK DONE BY CONTRACTORS:

In order to get the stripping work started more quickly, without waiting for the delivery of excavating equipment and also because of the relatively short life of the property, it was decided to do the preliminary stripping work by contract. The stripping contract was awarded to the Isbell Construction Company.

Construction work was also done under contract, the camp being constructed by the Utah Construction Company, and the mill by the Stearns-Roger Manufacturing Company.

STRIPPING AND MINING:

Stripping at the Oxide pit was started late in December, 1951, and built up from 4,000 tons that month to over 500,000 tons the following May. By May 1953, a rate of 1,000,000 tons per month was reached. At that time two 6-yard shovels, one 3-yard shovel, seven 22-yard trucks, seven 15-yard trucks, six churn drills, one rotary drill, three D-8 caterpillars, one DW-10, one grader and various service trucks were in use. The stripping rate has decreased to 500,000 tons per month, and this pit is currently producing one-third of the daily ore tonnage. By January 11, 1956, 18.5 million tons of waste and 4.6 million tons of ore had been removed from the Oxide Pit.

During preliminary stripping operations, a drainage dike to the north of the pit was constructed with 3,000,000 tons of waste from the several higher benches on the north and east sides of the pit area. Another 2,200,000 tons was moved to the east of the pit area, and the balance of the waste and oxidized material was moved to the southwest of the pit. Topography was such that over 90 percent of the waste was disposed of within 100 feet of its original elevation, even though waste was stripped over a vertical range of 400 feet. All waste disposal road grades were held under 7 percent. The average length of haul has been 0.8 miles, with only a small tonnage being hauled over one mile.

Stripping was started at the El Tiro pit in March, 1953. The stripping rate has built up to 600,000 tons per month, and this pit is currently producing one-third of the ore tonnage. Eventually, one half of the daily tonnage will be from each pit. By January 31, 1956, 10.3 million tons of waste and 500,000 tons of ore had been removed from this pit.

The topography of the El Tiro area is similar to the Oxide area, and as in the Oxide pit, over 90 percent of the El Tiro waste was disposed of within 100 feet of its original elevation. During this preliminary stripping, 4,000,000 tons were moved to the east of the pit, 4,000,000 tons were moved to the northeast of the pit, and the balance of the waste and oxidized material was moved to the west of the pit area. The length of haul for the El Tiro waste has averaged 0.4 miles, and has never exceeded 0.8 of a mile.

The length of ore haul, 4 miles from pit perimeter to the mill, presented some interesting problems.

The sub-grade for this haul road was formed for one mile on each end with waste from the two pits. The two-mile central portion was brought to grade by balancing cuts and fills. A maximum grade of two percent was maintained.

To obtain low truck maintenance, good tire cost and avoid continuous sprinkling and grading, the El Tiro road was paved.

To further reduce haulage costs, six new trucks were put into service for the El Tiro ore haul. This unit is the Kenworth 802-B truck-tractor with dump semi-trailer. This truck-trailer combination is powered by a turbo-charged NRT-600 Cummins diesel producing 300 hp, and has a capacity of 32 cubic yards (struck). Further details on these haulage units can be obtained by referring to a paper entitled "A Discussion of Rear Dump Trailers", by Furman Byars, presented at the annual meeting in Tucson, Arizona, December 1955.

The equipment currently in use at Silver Bell consists of: Three 6-yard electric shovels, (two in the El Tiro pit and one in the Oxide pit), three 3-yard diesel powered shovels, (one in El Tiro and two in the Oxide pit). eight 15-yard trucks, seven 25-yard trucks, six 32-yard trucks, one rotary drill, eight churn drills, two DW10 tractors, two D-8 caterpillars, one road grader, and various service trucks.

PIT LAYOUT

Both the El Tiro Pit and the Oxide Pit have been laid out on a 1 to 1½, or 56° back slope. The shape and size of the ore body governs the selection of this slope. The rock is reasonably firm, there are no known faults parallel to the perimeters, and the life of both pits is comparatively short, 12 years, so little difficulty from slides of rock is expected with a 1 to 1½ slope.

A bench interval of 30 feet was originally planned, but this was later changed to 40 feet. The main reason for this change was to permit the contractor, Isbell Construction Company, to use their 6-yard shovels to a better advantage. Some of the lower benches may be mined on a 30-foot interval.

SUMMARY:

In summary, the two ore bodies have a reserve of 32,000,000 tons, the majority of which are in the Oxide ore body. The average assay of the two pits, four miles apart by road, is 0.9 percent copper. The combined stripping ratio for the two pits is 1.2 waste to 1 ore. Present pit equipment with truck haulage and modern milling practice, make the operation feasible.