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UPDATING THE GEOLOGY AND STRUCTURAL ORE CONTROLS AT SILVER BELL, ARIZONA

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MAY 22 1968
DEPT. MINERAL RESOURCES
PHOENIX, ARIZONA

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A talk to be presented to the Mining Geology Division of the Arizona Section of A.I.M.E. on May 20, 1968.

One of the more complete stratigraphic sections in southern Arizona can be pieced together in the Silver Bell area. Much of the geology has been worked out by ASARCO geologists, while a few important areas have been mapped by students as thesis problems. Other portions of the Silver Bell area have yet to be mapped in any kind of detail, and some of this yet-uncharted geology could well be critical to a better understanding of the complex Mesozoic and Cenozoic stratigraphy.

It is my strong belief that a knowledge of certain of the stratigraphic units in the Silver Bell area--their lithologic characters and structural settings--would be of considerable help to field geologists dealing with similar phenomena elsewhere in southern Arizona. Parts of the Silver Bell stratigraphic section are accessible only by washes or somewhat obscure truck trails, and other portions of the section are on, or readily reachable only by passage through, private property owned by ASARCO.

In the following, I will attempt to briefly describe the geologic history of the Silver Bell area, with particular emphasis on the Mesozoic Era. My knowledge of the area has been greatly enhanced through field excursions and conversations with Harold Courtright, Kenyon Richard, Jim Briscoe, Craig Clarke, Chuck Haynes, Nick Nuttycombe, Joy Merz, Fred Graybeal and Dr. Willard Lacy. I must take, however, the responsibility for the interpretations drawn herein.

Figure 1 is a location map showing the principal topographic features mentioned below. Figure 2 is my diagrammatic representation of the Silver Bell stratigraphic column.

PRECAMBRIAN

Pinal Schist

The only outcrop of the basement Pinal Schist known to the author in the Silver Bell vicinity straddles the El Paso Natural Gas pipeline road about two miles east of Ragged Top. Relationships with other rock units are obscured by cover, except on the south where the schist is bounded by a mid-Tertiary dike filling the major WNW-trending Ragged Mountain fault.

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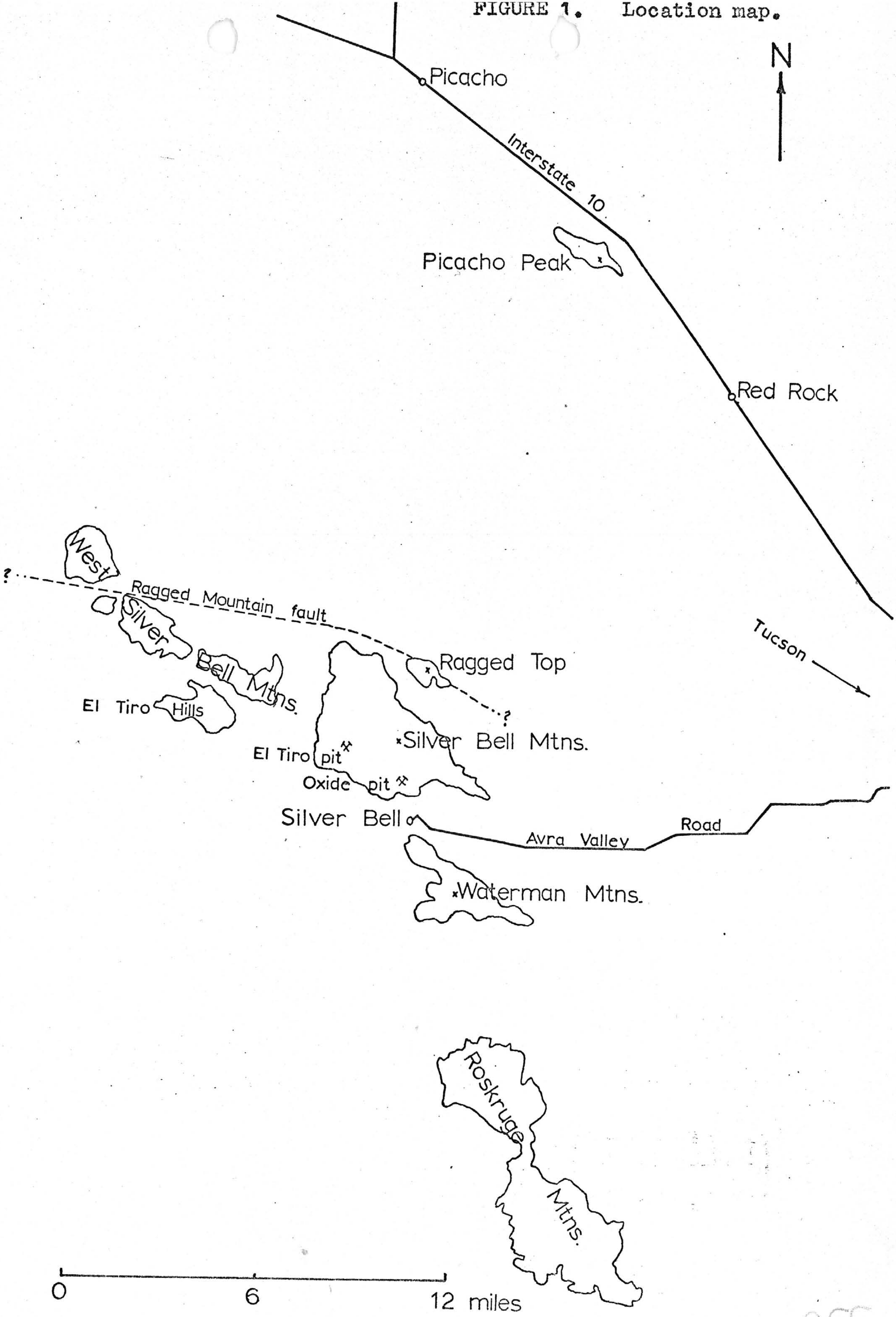
FIGURE 1. Location map.



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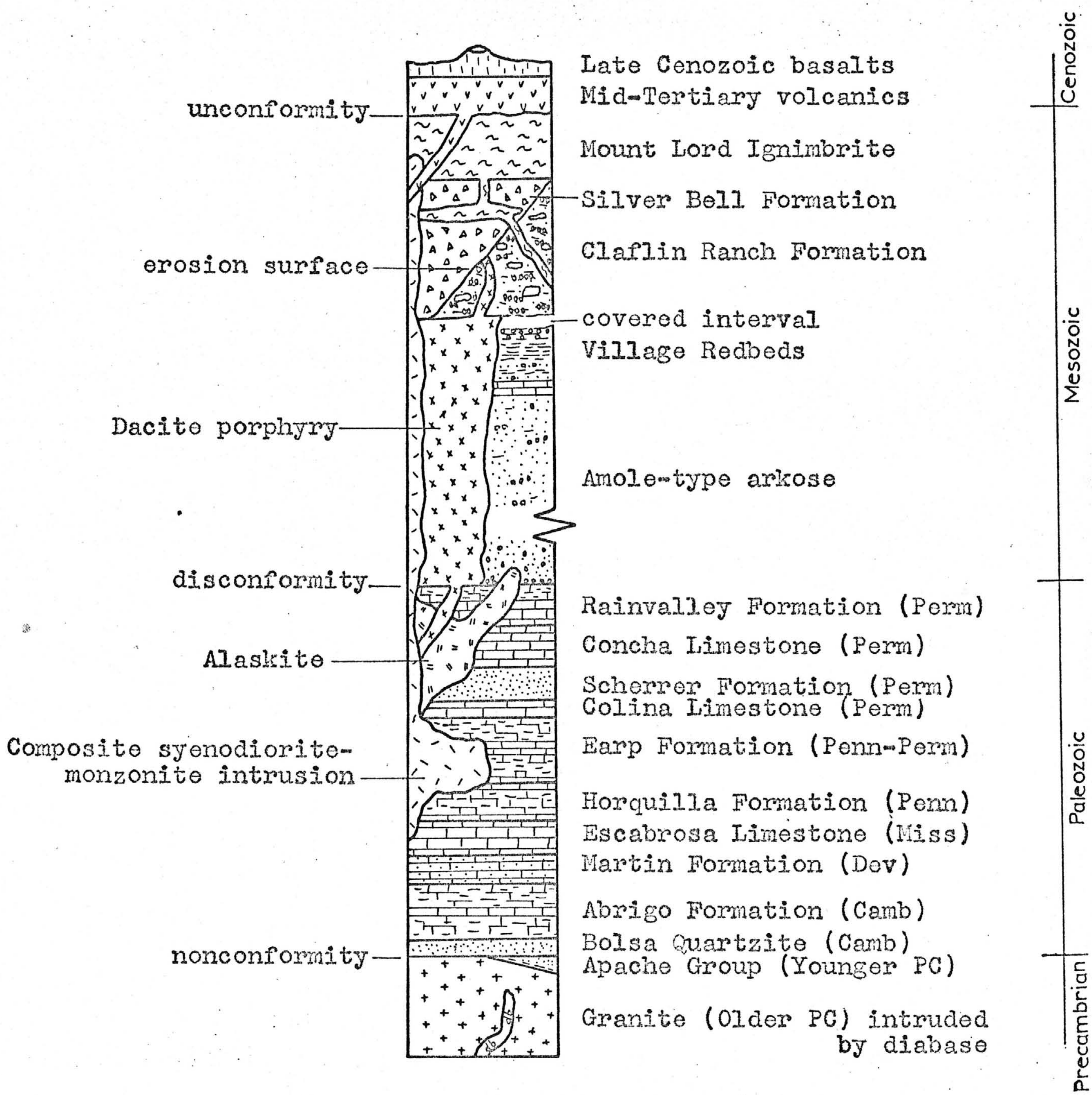

FIGURE 2. Diagrammatic geologic column of the Silver Bell area. Maximum known thicknesses for Paleozoic and Mesozoic rocks are shown. Scale of column: 1"=2000'.

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Many fragments (ranging up to boulder size) of Pinal-like schist are seen in Cretaceous sediments just south of Ragged Top, indicating the presence of a considerable area of that schist at the surface in the near vicinity during the Laramide igneous activity.

Granite

A coarse-grained granite is found extensively to the north of the Ragged Mountain fault. Large and numerous quartz grains--frequently .25 inch in diameter--are set among pinkish crystals of feldspar and clumps and books of biotite. In many places orthoclase porphyroblasts up to an inch in length are common. This granite megascopically resembles the Precambrian Oracle granite seen near the town of Oracle.

Paleozoic sediments in the Waterman Mountains southeast of Silver Bell are also underlain by porphyroblastic granite.

Apache Group

Younger Precambrian Apache Group metasediments lie on granite just northeast of Ragged Top. Locally more than 200 feet thick, these south-dipping beds are sharply cut off to the south by the Ragged Top intrusive which wells up along the Ragged Mountain fault. The Apache Group stratigraphy here is not well worked out, but it appears as if a few tens of feet of probable Pioneer Formation (mixed sandy and shaly beds) are overlain by 2-3 feet of Barnes Conglomerate, which is in turn overlain by thin-to moderately thick-bedded quartzites of the Dripping Springs Quartzite.

Apache Group metasediments are missing in the Waterman Mountains where McClymonds (1957) notes Cambrian Bolsa Quartzite to conformably overlie basement granite.

Diabase

Well-altered diabase of possible Precambrian age irregularly intrudes the granite on the northern slopes of Ragged Top. As it is found only within granite, it's relative age cannot be stated with certainty. The principal period of Precambrian diabase intrusion in southern and central Arizona is post-Apache Group.

PALEOZOIC ERA

The Paleozoic stratigraphy of the Waterman Mountains has been deciphered by McClymonds (1957) and Ruff (1951) who mapped a well-faulted pile of limestones, quartzites, siltstones, and shales amounting to a thickness of 4,400+ feet. In the Silver Bell Mountains, Paleozoic stratigraphy was unravelled by Kingsbury, Entwistle and Schmitt in 1941 in a private report to the American Smelting and Refining Co. Merz (1967) undertook the difficult study of the altered and mineralized Paleozoic sediments on Union Ridge east of ASARCO's El Tiro pit. The alteration and mineralization of these Union Ridge sediments will be described in the next paper this morning.

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The Paleozoic section in the Silver Bell Mountains is well faulted, locally intensely altered, and generally inundated by various Laramide intrusive units. Although each of the Paleozoic periods represented in the Waterman Mountains also show in the Silver Bell range, the section in the latter is obviously incomplete. A brief tabulation of units with thickness estimates is presented below:

Permian quartzites, limestones, shales..	550 ft. approx.
Pennsylvanian Horquilla Limestone.......	220 ft. max.
Mississippian Escabrosa Limestone.......	275 ft. max.
Devonian Martin Formation...............	300 ft. max.
Cambrian Abrigo Formation...............	430 ft. max.
Cambrian Bolsa Quartzite................	230 ft. min.
Total.....	2,005± ft.

In the El Tiro Hills section of the West Silver Bell Mountains, Clarke (1965) mapped 1,200+ feet of uppermost Permian sediments. Approximately 300 feet of quartzites and dolomitic limestones belonging to the Scherrer Formation are overlain by ±420 feet of Concha Formation Limestone and ±550 feet of Rainvalley Formation limestone and argillite. These Permian rocks protrude from alluvial cover and are overlain by Mesozoic sediments.

MESOZOIC ERA

Amole-type arkose

A clearly exposed contact between Mesozoic and Paleozoic sediments is found in the El Tiro Hills where Clarke (1965) has mapped an estimated 5,000+ feet of probable Cretaceous Amole-type sediments overlying Permian Rainvalley rocks. The basal Amole-type units, lying on a disconformity, is a massive arkosic conglomerate containing rounded quartzite cobbles up to several inches in diameter. This unit of the Cretaceous (?) is several feet thick; the remainder is generally more thinly bedded.

Hayes and Drewes (1968) consider the Amole Arkose of the Tucson Mountains to be more or less a time-equivalent of the lower Middle Cretaceous Bisbee Group sediments. If the Amole-type materials in the El Tiro Hills can be considered correlative with the Amole Arkose, then Clarke's basal quartzite pebble conglomerate qualifies as a far-western equivalent of the basal Bisbee Glance Conglomerate. The presence of Cretaceous (?) beds lying disconformably on the uppermost Permian Rainvalley certainly suggests that the Silver Bell area did not experience, at least locally, the degree of structural unrest manifested farther to the east.

Another interpretation suggested by the near-conformable nature of the Paleozoic-Mesozoic contact related to recent U.S. Geological Survey recognition of Triassic sediments in southern Arizona. Possibly the hiatus between Permian and Mesozoic deposition is not as great as might be thought, and the lowermost Amole-type sediments are of Triassic age?

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A few tuffaceous beds are scattered through the Amole-type arkoses, indicating periodic volcanic activity in the general region. Red-colored shales and conglomerates are found here and there through the sequence and are most prevalent in the upper portions. A 20-30-foot thick sandy limestone occurs near the top of the exposed older Cretaceous beds.

The Amole-type sediments are overlain in angular unconformity by interbedded tuffs and coarse clastic sediments of the Claflin Ranch-type. A similar mid-to late Cretaceous unconformity has been noted elsewhere across southeastern Arizona. It is felt that this unconformity reflects initial upheaval related to Laramide deformation.

Amole-type arkoses, conglomerates and sandstones also crop out in the valley between the Waterman and Silver Bell Mountains. Immediately overlying the arkoses near the southeast corner of the older Silver Bell tailings dam is a limestone unit probably exceeding 200 feet in thickness. Donald Bryant of the University of Arizona was able to identify recrystalized pelecypods here as of definite Cretaceous age. Outside of the Bisbee Group Mural Limestone, this localized unit is probably the thickest Cretaceous limestone known in southcentral Arizona.

Village Redbeds and red conglomerates

A sequence of red-colored clastics is found overlying the limestone unit and Amole-type arkoses south of the Silver Bell tailings dams. These clastics, which also underlie Silver Bell village, are locally several hundreds of feet thick, but faulting and alluvial cover prevent thickness determinations. The author originally considered this unit to be an equivalent of the Recreation Redbeds of the Tucson Mountains. However, detailed mapping plus radiometric age-dating have recently proven the Recreation Redbeds to be of pre-Amole age, and evidence is now overwhelming that red coloration represents restricted environmental conditions that could, and do, appear at various times throughout the Mesozoic. Consequently, I am here designating the Cretaceous redbeds and red conglomerates near the Silver Bell townsite the "Village Redbeds".

In places redbeds and light-colored Amole-type arkoses are found interbedded, suggesting a somewhat gradual transition from the Amole to the Village environment. Several hundred feet of red silts, sands and arkoses occur in the lower portions of the Village Redbeds and are seen to grade upward to red conglomerates. At first these conglomerates contain only sedimentary detritus. Higher in the sequence igneous materials begin to appear, however, and in the uppermost known portions the red conglomerate consists almost entirely of purple andesitic fragments set in a detrital matrix. Deformation of an ancient Silver Bell landscape and a gradual increase in volcanic activity is readily evidenced in the continuing deposition of the redbeds and red conglomerates. Thus the transition from normal Cretaceous subaerial sedimentation to coarse and rapid Laramide accumulation is not always marked by an obvious stratigraphic break.

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The Village red conglomerates are cut off by a major WNW-trending fault in the tailing pond area, and their relation to overlying units is not presently known.

Claflin Ranch Formation

The Claflin Ranch Formation is something of a catch-all term, and the rocks it represents are not limited to any one specific time of deposition. The formation represents a type of sedimentation associated with a terrane undergoing volcanic upheaval and rapid erosional deformation. Thus, in the Silver Bell Mountains where Richard and Courtright first used the name (1960), the conglomerates, mudflows, landslide blocks, aeolian tuffs, water-lain tuffs and pyroclastic layers included within the Claflin Ranch Formation have ambiguous relationships with associated volcanic units. They are pre-dacite and post-dacite, pre-Silver Bell andesite and post-Silver Bell andesite. In the West Silver Bell Mountains Claflin-like conglomerates are interbedded with pyroclastics and overlie earlier Cretaceous sediments by angular unconformity.

The thickest continuous Claflin Ranch sequence in the Silver Bell Mountains--approximately 1800 feet--occurs southwest of Ragged Top. This accumulation is, at least in good part, pre-dacite porphyry (the earliest of the Laramide volcanic and sub-volcanic rocks in the Silver Bell range). Coarse, greenish clastic materials megascopically identical with parts of the Claflin Ranch Formation are found as a matrix of the Tucson Mountain Chaos in the Tucson Mountains. Claflin Ranch-type rocks also are seen in roadcuts north of Sonoita along Arizona State Highway 83.

It seems reasonable to expect that the Claflin Ranch-type of surface accumulation of detrital and volcanic debris might be found throughout southern Arizona wherever Laramide volcanic piles exist. Such depositional sequences--seemingly thickest in earlier Laramide time--would run the gamut from fairly thin-bedded sands to chaotic masses of landslide-block accumulations.

Alaskite

Richard and Courtright (1966), in accounting for the WNW-striking zone of alteration at Silver Bell, conclude that "indirect evidence suggests a fault representing a line of profound structural weakness existed in this position prior to the advent of Laramide intrusive activity." This line is referred to as the "major structure." They go on to note that this major structure "was largely obliterated by the Laramide intrusive bodies, but it effected a degree of control on their emplacement, as evidenced by their shapes and positions."

The first indication of activity along the Silver Bell fault zone came in early Laramide time with the intrusion of a coarsely granitoid alaskite along the southwest side of the major structure. This alaskite, which contains a very low ferromagnesian mineral content, intrudes Paleozoic sediments and Cretaceous Amole-type arkoses in the El Tiro area. Aplite dikes are found through the alaskite, and, locally, fine-grained border phases of alaskite are found in contact with other rock units.

The alaskite is one of the principal hosts for the later porphyry copper mineralization. This coarse-grained felsic rock locally shows high chalcopyrite-to-pyrite ratios.

Dacite porphyry

The dacite porphyry is a sub-volcanic rock characterized by numerous rounded or triangular quartz "eyes" set in a very fine-grained matrix. Orthoclase and sanidine phenocrysts, vague but consistent flow structure, and up to 20% of xenoliths are also commonly seen. Chemically, the dacite porphyry is more accurately a quartz latite porphyry.

The dacite occurs extensively northeast of the major structure in the form of sills and dikes within Paleozoic and Mesozoic sediments. The largest body of the porphyry--a sill ± 3,400 feet thick--occupies the stratigraphic interval in the Silver Bell range proper where Amole-type arkose should occur. This sill is floored by Paleozoic sediments and roofed by an 1800-foot sequence of Claflin Ranch materials. The dacite-Claflin Ranch contact is gradational over several feet, but dikes of dacite porphyry are found locally in the overlying Claflin Ranch beds.

An explosive history for the dacite porphyry is strongly suggested by the numerous xenoliths, the large fragments of quartz, and the shards of former glass in the matrix. The nature of the rock is believed to reflect an emplacement by fluidization in the following manner:

The gas-and fragment-charged dacite porphyry magma (actually quartz latite in composition, suggesting greater viscosity and more explosive potential) rose along the Silver Bell fault zone into Paleozoic strata. The higher the porphyry magma ascended, the more the confining pressure decreased, causing exsolution of gases and thus lending an explosive and dilative nature to the intrusive material.

Its extension to the southwest blocked by the large body of alaskite, the dacite porphyry welled up, sending small dikes and sills northeastward into the Paleozoic beds. Damp Amole-type Cretaceous (?) sediments were reached and more gas evolved. The magmatic material, expanding constantly, spread laterally to the northeast in the weak Cretaceous (?) sediments. Dilation occurred, as did the incorporation of fragments broken by churning gas action.

The dacite porphyry probably surfaced in one or more places, venting gases as it did. Gas also escaped laterally through the just-formed sill and vertically into overlying Claflin Ranch sediments. The heat and vapor action altered the immediately overlying quartzo-felspathic clastic sediments, giving rise to the gradational contact seen today.

The dacite porphyry was a poor host rock for porphyry copper mineralization because of its flinty, "tight" nature.

Silver Bell Formation

The Silver Bell Formation (Richard and Courtright, 1960) consists of laharic, autobrecciated, and intrusive andesitic to dacitic breccias, andesitic to dacitic flows, and andesitic intrusions. These materials overlie Claflin Ranch sediments and dacite porphyry in the Silver Bell Mountains. The rugged nature of the basal Silver Bell contact and the fact that it locally lies on unroofed dacite porphyry points to a period of rapid uplift and erosion following intrusion of the dacite porphyry sills.

Purplish Silver Bell-type breccias are seen to be interlayered in places with overlying Mount Lord Ignimbrite. Such a transition from andesitic activity to more felsic and explosive volcanism is seen throughout the world and is commonplace in the Laramide rocks of southern Arizona and southwestern New Mexico.

It is believed that the Silver Bell Formation is roughly correlative with the Demetrie Formation of the Sierrita Mountains, the Picacho Peak volcanics (Briscoe, 1967), the Owl Head volcanics, and that portion of the Cloudburst Formation north and east of the San Manuel mine.

Mount Lord Ignimbrite

A welded ignimbrite lithologically similar to, and stratigraphically a time-equivalent of, the Cat Mountain Rhyolite of the Tucson Mountains overlies the Silver Bell Formation in the Silver Bell Mountains. This quartz latitic ignimbrite is up to 800 feet thick, including an 80-foot thick cap of lithic vitric tuff. As Silver Bell Peak was formerly known to residents of the area as "Mount Lord" and since the peak is composed of the pyroclastic unit, the name "Mount Lord Ignimbrite" has been given to this Cat Mountain-type unit.

Intrusive ignimbrites--genetically related to the Mount Lord Ignimbrite, and megascopically and petrographically identical with it--occur as dikes and sills in the underlying Silver Bell Formation and dacite porphyry. These feeder materials once en route to the surface spread along bedding and formational contacts, apparently when vents became choked.

The Cat Mountain Rhyolite of the Tucson Mountains evinces an average age of 68 million years (Damon, 1968), and it is felt that the Mount Lord Ignimbrite is of similar age.

Syenodiorite porphyry

The syenodiorite porphyry is an early and somewhat extensive pyroxene-bearing phase of the composite intrusive thought to be related to the copper mineralization at Silver Bell. Later phases of this composite intrusive are monzonitic and quartz monzonitic. The syenodiorite porphyry is found principally in the southeastern portion of the Silver Bell Mountains. It occurs as massive bodies in Oxide pit (where it was previously called both "andesite" and "dacite") and east of Oxide pit along the major structure, and is found as east-trending dikes north of Oxide pit in the mountain range.

The syenodiorite porphyry is the best host rock in Oxide pit. It shows the highest primary copper sulfide content of any of the igenous rocks at Silver Bell and has allowed precipitation of a substantial chalcocite blanket.

Only occasional dikes of syenodiorite porphyry are seen in El Tiro pit.

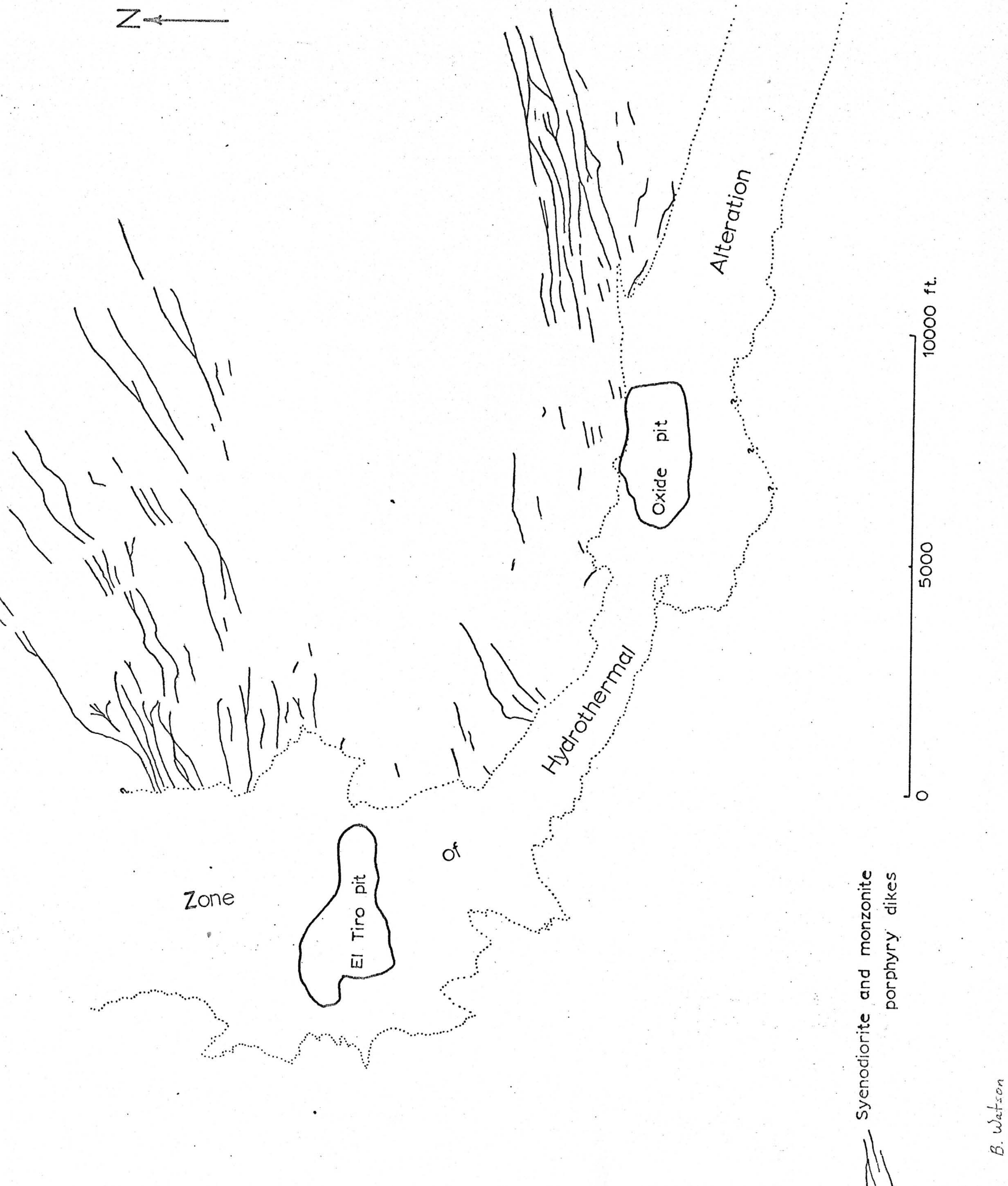
Monzonite porphyry

The later monzonitic and quartz monzonitic phases of the composite intrusion are found as massive bodies scattered along the major structure. They occur also as generally east-trending dikes in the mountain range to the northeast of the major structure.

The principal porphyry copper mineralization followed emplacement of the monzonite porphyry, and a zone of alteration was superimposed on the major structure. K-Ar age-dating (Mauger, Damon and Giletti, 1965) has shown that the solidification of the monzonite porphyry and the subsequent hydrothermal alteration occurred at approximately 65 million years and within a short enough time span so that, considering the limits of error of the age-dates, the two events are radiometrically indistinguishable. I do not mean to imply here that the Silver Bell deposits are to any great extent syngenetic as has been suggested recently (Mauger, 1966). It may be that a small amount of chalcopyrite became trapped as discrete grains in the monzonite magma at the time of solidification. The great preponderance of copper mineralization, however, was emplaced in the various host rocks through veins, veinlets, and hairline fractures with values diffusing into wallrocks, possibly with the aid of a certain amount of igneous rock recrystallization.

It is interesting to note that both the Oxide and El Tiro orebodies occur at structural intersections (see Figure 3). Oxide pit is located at the junction of the WNW-trending major structure with an ENE-trending swarm of syenodiorite and monzonite porphyry dikes. Similarly, El Tiro pit exists at the junction of the major structure with a northeast-trending swarm of monzonite porphyry dikes.

FIGURE 3. Dike swarms related to mineralization at Silver Bell



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CENOZOIC ERA

It is preferred here to set the Mesozoic-Cenozoic time boundary at 63 million years as defined by Folinsbee, Baadsgaard, and Lipson (1961). This allows the Silver Bell mineralization to fall at the end of the Cretaceous Period.

Regional northeasterly tilting of 20°-30° occurred sometime between the emplacement of the composite Laramide intrusion and the mid-Tertiary volcanism. It probably was a result of late Laramide upheaval. This tilting, shown by the present orientation of Laramide depositional units, appears to have taken place by rotation of WNW-elongate, fault-bounded blocks in the Silver Bell area.

The mineralized rocks at Silver Bell were exposed to weathering and probably supergene enrichment in early Tertiary time. This is strongly suggested 3 miles east of Oxide pit where pieces of leached capping were found in a conglomerate immediately underlying an andesite flow dated at 28 million years (Damon and Mauger, 1966). A mid-Tertiary period of rhyolitic to andesitic volcanism evinced widely over southern Arizona probably covered and thus preserved the Silver Bell mineralization. This mineralization has been exhumed in more recent times and is presently undergoing destruction through weathering processes.

North-northwest-trending quartz latite porphyry and andesite porphyry dikes of the mid-Tertiary volcanic epoch cut all earlier rock units in the Silver Bell Mountains. The quartz latite dikes have a strangely discontinuous line of outcrop which is caused not by faulting, as has been previously suggested by Schmitt (1941), but by intrusion into a very broken and faulted terrane. A few of the andesite porphyry dikes are conspicuous in El Tiro pit where they are locally collectors of green copper oxide.

The Ragged Top Latite Porphyry dated at 25±1.0 million years (Mauger, Damon and Giletti, 1965) intruded the prominent Ragged Mountain fault which had dropped Laramide rocks on the south some 5,000-7,000 feet against Precambrian granite. Andesitic and rhyolitic flows of probably similar age are seen several miles west of Ragged Top in the northeastern part of the West Silver Bell Mountains.

A late and minor lead-silver-copper mineralization is found in the Silver Bell range. North-trending epithermal veins carrying galena, native silver and cerargyrite with a barite-quartz-calcite-fluorite gangue were mined in the early days. Copper stain is seen on the old dumps. This later period of mineralization has been superimposed very locally on the porphyry copper deposits to the south. On the other hand, a mid-Tertiary quartz latite porphyry dike cuts one of the epithermal veins, thus establishing a general minimum date to this mineralization.

Quaternary-Tertiary basalt cones and flows are found north of the Ragged Mountain fault.

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ALTERATION AND MINERALIZATION OF THE PALEOZOIC
SEDIMENTS IN THE EL TIRO PIT AREA
SILVER BELL, ARIZONA

A talk presented at the Mining Geology Division of the Arizona Section of A.I.M.E.

May 20, 1968 Tucson, Arizona

by
James A. Briscoe
ASARCO Geologist

INTRODUCTION

This morning I'll attempt to briefly describe the geology of the sediments and the interrelated igneous rocks in the El Tiro pit area as it is presently known. Much of the data presented is based on a private report to the American Smelting and Refining Company by Mr. Stephen Von Fay. The stratigraphic interpretation of the Union Ridge area has been taken from a recent U of A masters thesis by Joy Merz. My knowledge of the area has been enhanced by discussions and field work with my co-worker Nick Nuttycombe, Mr. Harold Courtright, Mr. Barry Watson, and Mr. Charles Haynes. The views expressed this morning are, however, the responsibility of the speaker.

I'd like to thank the American Smelting and Refining Company for allowing me to present the talk. Speical thanks goes to the Silver Bell Unit of ASARCO, and Mr. D.R. Jameson, Superintendent of the Unit for making this meeting possible.

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HISTORY

History of mining in the Silver Bell district possibly dates back as far as Precolumbian times when Indians in the area dug shallow trenches along fracture zones and andesite dikes searching for turquois, hematite and clay. Large saguaro cacti growing in some of these workings indicate they are at least 200 years old.

The area first came to the attention of the white man in 1865 when prospectors located a small pod of enriched silver ore in the altered sedimentary rocks near the present southeast corner of El Tiro pit. Early efforts to mine silver in this area failed, probably due to the fact that Silver Bell has only weak sporadic occurrences of silver mineralization...

Well organized mining activity began in 1899 with the organization of the Silver Bell Copper Company, which evolved into the Imperial Copper Company in 1903. The Southern Arizona Smelting Company or SASCO, built a smelter near the northern end of the Silver Bell mountains giving rise to the small smelter town of Sasco, the ruins of which are still visable today. The Arizona Southern Railway hauled ore between the mines at Silver Bell and the Sasco smelter, both the railway and the smelter being subsidiaries of the Imperial Copper Company.

By 1910 the Company or its predecessors had done some 20.8 miles of underground work in removing about 700,000 tons of ore averaging approximately 3.7% copper. Yet even by accounting all profits including those from the smelter, the railroad, and the company store back to the mine, the company only showed a profit one year. Production ceased in 1910 with the company going into receivership, and later purchase by the American Smelting and Refining Company in 1917.

ASARCO operated the mine on a marginal basis until 1919 when all large scale mining was haulted, sporadic small scale production continuing until 1930. Although the possibilities of disseminated enriched chalcocite ore was recognized in 1909, an extensive drilling program indicated that the tenor was then subeconomic.

In the late forties ASARCO undertook a program of geologic mapping and exploratory and check drilling under the direction of Kenyon Richard and Harold Courtright. This resulted in the delineation of the Oxide and El Tiro enriched chalcocite ore bodies, production from which began in 1952.

The sedimentary rocks which had accounted for the early day production from the district were largely ignored during the first part of the open pit development. This was mainly due to the apparently small amount of mineralized sediments available for open pit operations. In addition, the early miners being interested only in the high grade pods of chalcopyrite, con-

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sidered anything below 3% copper as waste rock, giving the erroneous impression on old maps that the sediments contained widely scattered pods of high grade material in barren rock.

During a search through old records late in the 1950's, Mr. Steve Von Fay found assay records indicating areas designated as waste ran up to 2% copper. Also found was an old drill log showing mineralized sediments lying below poorly mineralized dacite between the edge of the pit and the outcropping mineralized sediments to the east. A detailed surface and subsurface mapping and sampling program was undertaken. This program was completed with favorable results and a drilling program was initiated. After three years of close spaced drilling, an ore zone of primary chalcopyrite, mineable for open pit methods was delineated.

GENERAL GEOLOGY OF THE EL TIRO PIT AREA

The El Tiro pit exposes all rocks typical of the alteration zone except for the syenodrorite porphyry which is the early phase of the monzonite porphyry. The main geologic features in the pit area are the mafic-free alaskite on the southwest and the dacite intruding Paleozoic sediments to the northeast. These two features are generally separated by the northwest trending El Tiro fault, a wide breccia zone which cuts all Laramide rocks in the pit, and is probably closely related to Richard and Courtrights ancestral "Major Structure". The fault zone appears to have been an important conduit for hydrothermal fluids during the period of mineralization, massive sulfides or strong alteration effects occurring throughout its length. Post mineral movement on the fault is indicated by brecciated and slickensided sulfides.

Two other northwest trending faults indicating recurrent movement along the northwest zone of weakness are defined by post-mineral andesite dikes. These dikes are Mid-Tertiary in age, similar ones being seen throughout length of the alteration zone.

The sediments to the east of the pit are intruded by the dacite in a sill-like manner. Drill hole data indicates the outcropping sediments are floored by the dacite, while the dacite just to the northeast of the El Tiro fault is underlain by sedimentary blocks. Several of these blocks are exposed in the southeastern corner of the pit and along the El Tiro fault zone, and more will be exposed as the pit is deepened.

Two stocks of monzonite porphyry are exposed in the pit. The stock to the southwest of the El Tiro fault is surrounded by alaskite, while the stock to the northeast of the fault intrudes the dacite containing large blocks of sediments and it is essentially bounded on the east, south and southwest sides by these sediments. The two stocks are connected by easterly trending dikes, and are undoubtedly connected in depth to a parent monzonite pluton. These two bodies, inspite of their genetic relationship, are quite differently altered and mineralized. The stock to the southwest of the El Tiro fault is strongly altered showing moderate to strong clay, sericite, secondary potassium feldspar, and silicification along with disseminated pyrite, chalcopyrite and molybdenite and an enriched chalcocite blanket. Moving easterly across the El Tiro fault the clay-sericite alteration becomes perceptably weaker in the monzonite dikes the stock itself being only weakly argillized with sparse to trace amounts of pyrite giving rise to scant limonite staining. There is no chalcocite enrichment, and the rock contains only trace amounts of primary copper. Easterly trending dikes radiating out from this stock, which cut the sediments, are occasionally so weakly altered that twinning of the plagioclase can be seen on a freshly broken surface. This lack of alteration of the monzonite I feel to be due to the fact that it is surrounded by reactive sediments. I theorize that the hydrothermal fluids that so strongly effected the monzonite stock to the southwest of the El Tiro fault were completely absorbed by and reacted with the limy sediments surrounding the stock to the northeast of the fault, leaving that stock almost entirely uneffected by hydrothermal alteration.

The presence of the sediments had a similar effect on the dacite, so that poorly altered and mineralized dacite may be underlain by sediments containing primary chalcopyrite ore.

ALTERATION AND MINERALIZATION OF THE SEDIMENTS IN THE EL TIRO PIT AREA

Although the sediments have been intruded by three different Laramide igneous rocks, namely the alaskite, the dacite and the monzonite, the effects of these intrusions are hard to evaluate. The dacite was relatively cool and gas charged at the time of intrusion and had apparently little metamorphic effect on the sediments. The alaskite and monzonite intrusions may have marbleized the limes and hornfelzed the shaley rocks to some extent. These effects are almost entirely obliterated, however, by the later intense effects which accompanied the hydrothermal mineralization.

In the igneous rocks to the southwest of the El Tiro fault innumerable parallel, easterly trending fractures localized and formed the plumbing for the hydrothermal solutions. This easterly direction of tension fractures also controlled the earlier emplacement of monzonite dike swarms in the El Tiro Oxide pit areas. This same easterly trending tension fracture direction appears to be the structural control for emplacement of ore fluids into the sedimentary rocks.

The ore fluids which permeated the sediments along the easterly trending plumbing system carried silica, iron, sulfur, possibly some potassium, aluminum, and magnesium, along with copper, zinc, molybdenum and minor lead and silver, these last two elements possibly being late stage or even Mid-Tertiary in age.

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The hydrothermal fluids altered the sediments to quartzite, marble, hornfels and tactite. The terms quartzite and marble are used in the normal sense and indicate an indurated and silicified sandstone and a recrystalized probably originally rather pure limestone. The terms hornfels and tactite are more ambiguous and have been defined for use at Silver Bell as follows:

> Hornfels is a fine textured rock consisting of varying proportions of lime-silicates such as diopside, epidote, chlorite, feldspar and quartz along with occasional garnet. It is derived from shales, from thinbedded argillaceous limestones and from mudstones and siltstones.

> Tactite is a medium textured rock composed of a number of lime-silicate minerals with predominate garnet. It is usually considered to be derived from impure limestones.

In a broad sense the hornfels and tactite units reflect different stratigraphic units, however, locally they are intermingled within individual horizons.

Generally speaking the impure limes and limy argillaceous rocks appear to be more receptative to metasomatism and are therefore good hosts for mineralization.

Garnet (low iron-$CaAl_2(SiO_4)_3$ high iron-$CaFe_2(SiO_4)_3$) diopside, $CaMg(SiO_3)_2$ tremolite-actinolite $Ca(MgFe^{2+})$ Si_8O_{22} $(OH,F)_2$ wollastonite $CaSiO_3$, chlorite and hydrobiotite are the most important gangue minerals.

Garnet in the ore bearing areas is usually brown in color. Chemical analyses indicate it is composed of equal parts of calcium bearing grossularite garnet and iron rich andradite garnet. This appears to represent iron metasomatism and is contrasted with the greenish garnet, probably mainly calcium rich grossularite which isn't usually associated with ore grade mineralization.

Diopside may represent silica metasomatism of dolometic limes, or merely recrystalization, with the aid of hydrothermal solutions, where sufficient silica as sand was already present.

Wollastonite represents silica metasomatism of limestone. In wollastonite hornfelses it probably represents reaction of the lime and silica already present, assisted by the presence of the hydrothermal fluids.

Increasingly large amounts of metamorphic rock composed mainly of hydrobiotite and chlorite are being found in the pit. This is particularly true along the El Tiro fault and other major hydrothermal channelways, where crystals of hydrobiotite up to two inches across can occasionally be seen. In some places the massive mica-rock is richly intergrown with chalcopyrite. The presence of biotite or chlorite appears to be a fairly good ore guide. The alteration is thought to represent iron, potassium and possibly aluminum metasomatism in a water rich environment.

Chalcopyrite is the only important sulfide copper mineral in the sediments. In areas in the orebody, sphalerite is closely associated with chalcopyrite. In some cases the chalcopyrite is found in solid solution with the sphalerite with exsolution of the chalcopyrite from the sphalerite being clearly seen under the microscope. As no zinc is recovered, where the two minerals are found in solid solution, the sphalerite acts as a diluent because no clean separation can be made between the two minerals in the mill.

Molybdenite occurs in the sediments as disseminations, as "paint" along fractures and with quartz veins in about the same quantity as occurs in the igneous rocks.

Iron as hematite and magnetite, magnetite being most important, appears to be closely associated with the copper mineralization. The occurrence of magnetite varies from disseminated grains to massive pods of the mineral cut by veins of chalcopyrite. This close association with chalcopyrite has made the magnetometer a very useful tool in the search for ore.

Pyrite, though occuring ubiquitously through the metasediments in minor amounts, appears spatially segregated from the chalcopyrite when it occurs in massive form. Drill holes have encountered as much as 100 feet of massive intergrown pyrite and magnetite.

Small occurrences of galena, sometimes quite argentiferous, have been seen, but these are not economically significant. They are either late mineral or may be associated with the Mid-Tertiary activity.

As mentioned previously, the introduction of the hydrothermal fluids was accomplished along easterly trending structures. Most of the disseminated chalcopyrite is associated with small quartz veins, with chalcopyrite disseminating out from the central conduit.

All graduations, from mineralization confined to the vein, to blebs of chalcopyrite disseminated through the rock but associated with vein conduits, to more intense mineralization where most of the gangue minerals have been replaced by sulfides, can be seen in the ore body. Even the massive replacement type mineralization appears to be associated with easterly trending structures, though this relationship is sometimes obscure.

Argillaceous or dirty limestone horizons appear to be particularly favorable for the deposition of ore, where these occur along an ore fluid conduit. Pure limes and of course quartzite horizons are unfavorable for ore deposition, however, along fissures marble will be metasomatized to garnet and carry some chalcopyrite.

OXIDATION OF THE ORE-BEARING SEDIMENTS AND THE OXIDIZED OUTCROP AS A GUIDE TO ORE

The mineralized sediments which outcrop have been oxidized to varying degrees. That is, oxidation may extend to a depth of inches or fractions of an inch or to a hundred feet or more, dependent mainly on permeability due to faulting and fracturing. In most cases, sulfides may be found close to the surface, at least locally.

Because of the high carbonate content of even the most intensely altered rocks, the copper from oxidizing sulfides is almost immediately precipitated in the form of copper carbonates, and therefore, there is no enriched chalcocite blanket. This is important in that copper values found at or near the surface are indicative of the values to be expected in the sulfide zone, providing there is no change in the chemical favorability of the rock.

Important oxide minerals are the black copper oxides, tenorite, and melaconite, the brown amorphous iron-copper complex known as copper pitch, and the copper carbonates malachite and azurite.

Chalcopyrite undergoing oxidation usually first alters to the brown copper pitch. This further reacts with the surrounding carbonate to form malachite. In many cases all that remains of the original chalcopyrite is copper pitch and some malachite, although the copper content of the rock does not change with the oxidation.

The oxidized outcrops of the orebearing metasediments are usually black and lava-like in appearance, with white quartz veins which were the conduits for the mineralizing solutions standing in relief. In many cases copper minerals are not visable except in protected crevices or fissures. The dark coloration is due to manganese and hematite, probably derived mainly from the oxidation of sulfides, but possibly due in part to hydrothermal hematite, and breakdown of iron rich garnet.

On breaking into the rock copper pitch, malachite and possibly even remanent chalcopyrite may be seen.

PALEOZOIC STRATIGRAPHY IN THE UNION RIDGE AREA

Because of the complex structure and intense alteration of the sediments in the El Tiro area, all attempts to work out their stratigraphy by early workers proved fruitless.

The intensity of the alteration is exemplified by the fact that the early workers thought that the Bolsa quartzite, which crops out to the north of the pit, was merely intensely silicified igneous rock.

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The stratigraphy was worked out by Mr. Joy Merz in 1967, as his Masters thesis problem at the U of A.

Using the idea that specific sedimentary rocks types when altered would yield specific metamorphic equivalents, and working from the numerous drill logs from holes in the area, Mr. Merz was able to piece together a logical stratigraphic sequence.

His work shows that the pure monomineralic rocks such as quartzite and pure limestone were poor hosts for metasomatism and copper mineralization, the best host rocks being impure limestone and limy siltstones.

The stratigraphic sequence in the Union Ridge area is the Lower Paleozoic sequence of the Bolsa quartzite through the Escabrosa limestone. Because of their impure thinbedded argillaceous nature, the lower Abrigo, the Upper Abrigo, and the Lower Martin limestones are the best hosts for ore, while the Bolsa quartzite, the more pure Middle Abrigo, and the Escabrosa limestone are relatively unmineralized.

SUMMARY

In summary, the Lower Paleozoic sediments in the El Tiro area have been altered and mineralized by the same hydrothermal fluids that altered and mineralized the Laramide igneous rocks.

Although easterly trending structural conduits were important, the mineralizing solutions preferentially metasomatized and mineralized thinbedded units of the Lower and Upper Abrigo formation and the lower part of the Martin limestone. The mineralized sediments form an orebody amenable to open pit mining.

This alteration and mineralization appears typical of limy sediments which are adjacent to bodies of copper bearing porphyrys, similar examples being seen at Santa Rita, New Mexico; Ely, Nevada; the Pima district sout of Tucson, and elsewhere.

S64X - 4,000 [illegible] per day
Lead -

SILVER BELL CONCENTRATOR

By Norman Weiss, Milling Engineer, Member A.I.M.E., American Smelting and Refining Company, Tucson, Arizona. July 1954.

Brought up to date by R. M. Darrah, Junior Metallurgist, Junior Member A.I.M.E., American Smelting and Refining Company, Silver Bell, Arizona. March 1967.

This paper is to be presented at the Spring Meeting of the Minerals Beneficiation Division, Arizona Section A.I.M.E., Silver Bell, 1967.

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SILVER BELL CONCENTRATOR

By Norman Weiss, Milling Engineer, Member A.I.M.E., American Smelting and Refining Company, Tucson, Arizona, July 1954.

Revised to conform with existing conditions by R. M. Darrah, Junior Metallurgist, Junior Member A.I.M.E., American Smelting and Refining Company, Silver Bell, Arizona, March 1967.

The 11,000 tons-per-day Silver Bell open-pit copper mining operation of the American Smelting and Refining Company is situated in Pima County, in the Silver Bell mountains about 35 airline miles northwest of Tucson, Arizona. Access is by road which turns west from the Casa Grande highway (Interstate 10), near Rillito. The 11,000-ton mill, which will be described in this paper, is now treating ore from the Oxide pit a half mile away, and the El Tiro pit 4 miles distant.

HISTORY

Silver Bell was not a new discovery. Over ninety years ago the Boot Mine operated only one-half mile east of El Tiro and later became the Mammoth Mine. The Silver Bell district, with its various mines, showed increased activity in the late 1880's. A factor in this was the arrival of the Southern Pacific railroad at Red Rock on its way west. The Imperial Copper Company was formed in 1903, and in 1907 the El Tiro Copper Company came into being as the successor to the Cleveland Arizona Copper Company. A concentrator was built near the Mammoth Mine and a railroad ran from the mill to Red Rock. In 1907 a copper smelter was built at Sasco, located 14 miles northwest of Silver Bell.

All of these, mill, railroad, smelter, and hamlets called Silverbell and Sasco, have now vanished, but up to 1930 they had produced over 70,000,000 pounds of copper and a little lead and silver.

The American Smelting and Refining Company entered the district in 1915 and through the years consolidated the separate holdings as opportunities were presented. From time to time, estimates were made with the thought of developing the property, but copper prices in relation to construction costs did not make the project attractive.

In 1948 an exploration camp was set up to check drilling and to continue exploration work. This work increased the ore reserves sufficiently to encourage the Company to develop the property under prevailing copper prices with the assurance afforded by a government floor price contract for part of the production.

Stearns-Rogers Manufacturing Company of Denver was engaged to construct the milling plant. Work on the site was started in June 1952 and terminated in February 1954. Test running was begun in March, and regular operations on a 24-hour basis was started in a few days.

CHRONOLOGY OF MAJOR EVENTS 1954 - 1967

The following is a brief chronology of the principal mill changes and additions since 1954:

March 1954:	Startup of original 7500 tpd concentrator, 4 grinding sections, each consisting of a fine-ore bin, a 10-ft 6-in. dia. by 12-ft grated ball mill, and an Akins 78-in. duplex classifier. Fine crushing section designed for either open-circuit or closed-circuit operation.
July 1954:	Converted fine crushing section to closed-circuit operation.
May 1956:	Started molybdenite recovery section using ferrocyanide, cyanide, sulphuric acid similar to Morenci process.
November 1957:	Replaced Akin classifiers with hydrocyclones.
April 1962:	Started new molybdenite recovery section using dextrin depression, roasting (heating), and reflotation.
February 1963:	Added the 5th fine-ore bin and ball mill circuit, raising daily tonnage to 9500; increased rougher flotation capacity by 25%. Lengthened grinding and flotation floors by 40 ft.
January 1964:	Started using new tailing dam.

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April 1966: Added double-deck screen ahead of 7-ft. standard Symons crusher, replacing stationary grizzly.

May 1966: Added the 6th fine-ore bin and ball mill circuit, raising daily tonnage to 11,000.

GENERAL FEATURES

The property lies at the west end of the broad Avra Valley, now becoming well-known for its production of fine cotton. The terrain slopes gently for nine miles from the valley floor at elevation 2020 feet, up to the town of Silver Bell, elevation 2650 feet, population about one thousand, established 1952. The mill is situated 100 feet higher, and at this point the grade increases sharply to the top of Portland Ridge (elevation 3315), which stands as a natural curtain between Oxide pit and the plant.

The general layout of the concentrator and auxiliary buildings is illustrated in Figure 1. Most of these buildings are of conventional reinforced concrete ans steel construction with galvanized corrugated steel roofing and siding.

GEOLOGY AND MINERALOGY

Silver Bell's two ore bodies lie separated by four miles within an elongated zone of alteration and mineralization. The zone is structurally controlled and has been the site of multiple Laramide intrusions. Prior to intrusion, sequences of Paleozoic and Cretaceous sediments occupied the zone. Only a relatively small portion of these sediments remain and they are variously altered and mineralized as are the igneous rocks.

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The primary mineralization is pyrite and chalcopyrite occuring both as disseminated and silicified fractures. These primary minerals have been subjected to weathering and oxidation with the resultant development of secondary chalcocite. This chalcocite occurs as coatings on and replacements of lower pyrite and chalcopyrite. This stage of enrichment has formed "blankets" which, in the areas of the pits, are up to 200 feet thick and represent an upgrading of 2 or 3 times the protore grade.

Within the sediments the ore mineral is chalcopyrite which occurs both disseminated and as massive replacements. Sparse molybdenite occurs associated with the copper mineralization, but has undergone no enrichment.

Some confusion has resulted from the name "Oxide" which applies to one of the pits providing sulphide ore to the mill. This name originated from the fact that the area was first drilled, about 1910, by the Oxide Copper Company, acquired by American Smelting and Refining Company in 1940.

For further details on the geology of the Silver Bell area, the reader is referred to "Structure and Mineralization, Silver Bell", which was published last in "Geology of the Porphyry Copper Deposits, Southwestern North America". This volume was edited by Spencer R. Titley and Carl L. Hicks and published in 1966.

CRUSHING

The arrangement of the crushing plant (Figure 2) provides low-cost operation by virtue of simplicity and compactness. All four crushers are under one roof and a traveling crane. Conveyors occuy the minimum amount of building space. Closed-circuit crushing is employed.

The work of this plant is to crush 11,000 tons per day of pit ore to ball mill feed size of all-pass one-half inch. The crushing section consists of the crushing plant building, served by a 50-ton Shaw-Box crane with a 15-ton auxiliary hoist; the conveyor drive house, which contains transfer conveyor 4 and the motors, drive mechanisms, and take-ups for conveyors 1, 2, 3, and 5; the coarse ore storage (stockpile and bins) and feeders; and connecting conveyors, dust control system, and other auxiliaries.

Ore is hauled to the primary crusher in 80-ton KW-Dart semi-trailer dump trucks, and dumped into the feed hopper of a 48-in. Traylor "TC" gyratory crusher. After reduction to 6-8 inches, the product drops directly upon a 72-in. Stephens-Adamson pan feeder, and then to belt conveyor 1. Coarse ore storage consists of a 3,000 tons total capacity steel bin and 25,000 tons total capacity stockpile which receives ore from conveyor 1. The bin receives ore directly from conveyor 1 while the stockpile receives ore from the intermediate 48-in. stacking-out conveyor 15. At any one time, ore is delivered to the bin or stockpile, but not both. The coarse ore bin and stockpile combined provide storage for 3 to 4 days with the help of a bulldozer. Close liasion with the two pits, shop and office is provided by radio.

Flow of ore from the stockpile is regulated by a variable speed, 42-inch traveling belt feeder (conveyor 17) which draws from nine individual draw points. The belt feeder speed control is actuated by the secondary crusher operator. From the belt feeder ore is discharged onto conveyor 16 which feeds conveyor 2.

Flow of ore from the bin is regulated by two Stephens-Adamson tunnel loading gates and two 48-in. flat belt feeders. The gates are hinged and counter-weighted, and control is provided by depth of bed regulation and variable speed drives, actuated also by the secondary crusher operator. The belt feeders discharge onto an impact conveyor which feeds conveyor 2. Ore can be drawn from the stockpile and bin simultaneously or individually.

Secondary and tertiary crushing equipment, consisting of one heavy duty 7-ft. Symons standard and two heavy duty 7-ft. Symons short head cone crushers, is housed in the same building as the primary (gyratory) crusher. The ore from the coarse ore storage crosses an Allis-Chalmers 6-ft. x 12-ft. double deck vibrating scalper screen situated ahead of the standard cone crusher, consisting of a 1-1/2 in. grizzly deck over a 3/4 in. square aperture screen. All minus 3/4 in. (98% minus 1/2 in) ore is collected on a 24-in. conveyor 20 which also collects all other screen undersize. Screen oversize proceeds by conveyor 19 and and fed to the standard cone crusher where it is crushed to approximately 1-1/2 in. and then discharged onto conveyor 3. The twice-crushed ore now proceeds by conveyors 3, 4 and 5 to the screens which precede the third and final crushing stage.

Four Tyler 6 x 10-ft. single-surface Ty-Rock F-180 screens with 1/2 in. square apertures remove the finished ore ahead of the tertiary crushers. The oversize product from the screens passes through the tertiary crusher and is carried on 36-in. conveyor 5C to conveyor 3 where it joins the secondary crusher product. These products then feed to the same Ty-Rock screens giving a closed-circuit operation. The undersize product from the screens joins the scalper undersize and is carried by 36-in. conveyor 6 over a Merrick Weightometer to conveyor 7 on the fine-ore bins. The ore is discharged by a Robins type S motorized tripper.

The plant was originally designed for 1000 tph in the primary section and 500 tph in the secondary and tertiary sections in closed-circuit operation. With the

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1965-66 expansion program, the secondary and tertiary sections were increased to 600 tph through the addition of the double deck screen ahead of the secondary crusher.

Fine ore storage consists of 6 cylindrical steel bins 40-ft. dia. x 58-ft. high, each with a volumetric capacity of 2000 wet tons, totaling 12,000 wet tons, based on 20 cu ft of ore per ton. The actual draw capacity is approximately 50% of these figures. The Robins tripper, motorized, does not travel continuously, but is spotted at a number of stations over the bins. The feed slot is sealed by means of a 22-in. dust belt over a safety grating.

Protection of crushing equipment from tramp metal is provided by two detramp electronic detectors on conveyors 1 and 2, and a 49-in. x 65-in. suspended magnet on conveyor 2.

Rock boots are installed wherever advisable to lessen impact on belts, and chutes are lined with manganese steel or rubber at points where excessive wear can be expected.

Conveyor belts are spliced by vulcanization, the longer belts field-spliced and the shorter ones supplied endless. The larger pulleys are straight-face. Most conveyors are chain-driven from gear reductions coupled to squirrel-cage induction motors through centrifugal couplings. Conveyors 19, 20, and 21 are belt-driven with shaft-mounted gear reducers.

A Nock & Garside freight elevator of 4,000 lb capacity runs from the basement of the crushing plant to truck-dump level, with four entrance landings.

<u>Interlock System</u> - The electrical interlock system is so arranged that stopping any machine will automatically stop all ore-carrying equipment preceding it,

but the shutdown of any ore-carrying device does not stop a crushing or screening unit.

Failure of a lubrication system automatically causes shutdown of the corresponding crusher. In case of excessive or insufficient flow of oil or high temperature an alarm system is energized, providing audible and visible signals and also actuating a time relay which shuts down the crusher. The time between signal and shutdown may be varied between 3 and 5 minutes.

The sequence of starting and interlock is given below, with other causes for automatic shutdown:

<u>Primary Circuit</u>

1. Belt conveyor 15 (to stockpile)
   a. High level in coarse-ore stockpile.
   b. Belt misalignment.
2. Belt conveyor 1
   a. High level in coarse-ore bin and/or stockpile.
   b. Belt misalignment.
   c. Detramp detector.
3. Pan Feeder
4. Primary crusher (not stopped by 1, 2 or 3)
   a. High-low oil flow (after time delay).
   b. High oil temperature (after time delay).

<u>Secondary Circuit</u>

1. Belt conveyor 7, 6, 5C, 21 and 20
   a. Belt misalignment.

2. Tertiary crushers (not stopped by 1)

    a. High-low oil flow.

    b. High oil temperature.

3. Screens (interlocked only for starting)

4. Belt conveyors 5, 4, and 3

    a. Belt misalignment.

5. Secondary crusher, stopped only by

    a. High-low oil flow.

    b. High oil temperature.

6. Belt conveyors 2, 10, 1A and 1B

    a. Belt misalignment.

Selector switches are provided so that one or more of the four screens or one of two parallel crushers or belts can be operated with the others idle.

Conveyor interlocking is accomplished by use of plugging switches on pulleys other than the drive pulley.

An inter-communication system saves the operators many steps, with stations at the following strategic points: top of coarse-ore bin, discharge of coarse-ore bin, conveyor drive house, primary crusher control panel, secondary and tertiary crusher control panel, pan feeder, gallery of conveyor 6, and top of fine-ore bins.

Closed-circuit TV stations are situated on the primary crusher observation floor and on the Symons crusher operating floor to enable the crushing plant operator to watch ore loading and transfer at several critical points in the conveyor system.

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Dust Control - In general, the system is arranged to draw dust-laden air down through the generating point, rather than counter to the flow of ore. Dust is picked up whenever possible from relatively large enclosures, the fines entering at one end under a curtain and then expanding to fill the space while dropping out coarser material. A basic velocity of 3500 fpm is used, and this is increased to 4,000 fpm at the collector, then reduced to 2500-3000 fpm through fan and stack.

At the secondary crusher, air is exhausted from the scalper screen, crusher-feed hopper, crusher-discharge hopper, hopper discharge to conveyor 3, and the junction of the scalper screen undersize and conveyor 20.

At the tertiary crusher, air is exhausted from the surge bin which feeds the four screens and the screen-undersize hopper. Also air is drawn from the tertiary crusher-feed hopper, crusher discharges, and at the point where the screen undersize meets conveyor 6. About 5,000 cfm is exhausted from conveyor 3 to 4 and 4 to 5.

Two Rotoclones serve the above collection points. The first exhausts 35,000 cfm from the primary and secondary crusher circuits. The second exhausts 25,500 cfm from the tertiary circuit.

In addition to the two wet collectors, two 5500 cfm Wheelabrator dry collectors operate on top of the fine-ore bins, exhausting from the conveyor 6 to 7 transfer, the tripper on conveyor 7, and from the fine-ore bins. The bags are shaken mechanically, and the dust is dropped into the fine-ore bins.

Water sprays are installed at strategic points throughout the crushing plant to lay the dust.

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GRINDING AND FLOTATION

The concentrator building covers 47,335 sq ft and includes these main sections: Grinding floor 67 x 362 or 24,255 sq ft, flotation floor 92 x 221 or 20,320 sq ft, and laboratories 46 x 60 or 2760 sq ft. The grinding floor contains six primary ball mills and their cyclones, and two regrind mills and accessories. The flotation floor contains the rougher, scavenger, cleaner, and recleaner flotation machines for the copper circuit plus "dextrin", refloat, and cleaner flotation machine for the molybdenum circuit. Both floors have space at the west end for normal repair service.

Figure 3 may be referred to in the following description of the flow sheet.

Grinding - Each of the six primary grinding sections consists of one fine-ore bin, one 10-ft 6-in. dia. inside shell x 12-ft effective length, Allis-Chalmers grate-discharge ball mill, and one 10 x 10-in. Linatex centrifugal pump feeding four Krebs D-20 cyclones. The ore at 1/2 in. size drops from the bin through three 2 x 2-ft. concrete openings into a steel discharge chute with adjustable swing gates. Two of the swing gates are controlled manually and one automatically. A 36-in. conveyor equipped with either a Merrick or a Fairbanks-Morse conveyor scale carries the ore to the ball mill.

The ball-mill feeder is a 72-in. radius, double rubber-lined scoop with ball charging drum. Primary mills were initially charged with balls of several sizes from 3 in. down, but at present the daily ration consists of 2-1/2 in. on Monday through Saturday and 3 in. on Sunday.

At the present only double-wave shell liners are used in the primary mills. The feed-end liners and shell liners are Ni-Hard alloy and the grates are of chrome-molybdenum alloy steel. The mills are driven by 900 hp synchronous motors at a speed of 18.05 rpm, equivalent to 74 percent of critical speed with new linings.

The primary classification at each mill is handled by a cluster of four 20-in. Krebs cyclones fed from a common header by a 10 x 10-in. Linatex horizontal slurry pump. Pump protection from tramp steel in the ball mill discharge is provided by hydraulic ball traps and large pump sumps. The pumps, which are equipped with manually-adjusted variable-pitch sheaves, operate at 370 to 400 rpm to compensate for wear on the cyclone apertures and pump parts, and draw from 22-23 hp, handling 1570 to 1670 gpm against 25 ft of total discharge head.

Automatic controls are used to keep the size distribution of the flotation feed approximately constant in the face of changing ore hardness. The "Float and Density" control system has proved to be the most applicable control. Any increase or decrease of density from a reference point is used to control the rate of feed to the circuits.

Pulp density of the cyclone overflow is measured by 2-in. straight tube Halliburton Densometer. An air signal from the Halliburton is sent to a Honeywell recorder-controller, which in turn sends an air signal to an index pointer of a Honeywell tonnage recorder-controller. The ratio between the index and indicator needles then sends another air signal from the Honeywell tonnage controller to an actuator with a side-mounted Moore positioner. The air motor positioner then regulates a swing gate on the fine-ore bin. This system gives excellent density control by varying the rate of feed of dry ore rather than a direct control of dilution water. A float valve is used to maintain a constant volume in the ball-mill discharge pump sump.

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The alkalinity of the flotation feed is controlled automatically. Electrodes measure the millivolts of the flotation feed on a Beckman pH amplifier which sends an electrical signal to a Honeywell recorder-controller. An air signal is sent from the controller to a Clarkson valve on the milk-of-lime loop, which opens or closes according to the desired alkalinity. The alkalinity can be controlled either automatically or manually.

A ball mill must often be positioned accurately for inspection, bolt tightening, relining, and other repairs. Because the load is unbalanced by virtue of the cascading ball charge, fluid pulp, and scoop feeder, such "spotting" or "inching" presents a problem. At Silver Bell, where there was no need for a heavy crane except for inching, an E-M Incher was installed, probably one of the earliest in this type of application, and has worked very satisfactorily. Inching by electrical means is accomplished by transferring the mill motor power feed from the normal 4160-V bus to the inching bus by a double-throw disconnect switch. The three inching buses alternately carry a D-C current from the motor generator set through contractors controlled by a timing device. This method transmits D-C power to the stator coils in phase group to cause rotation of polarity in slow motion. While stator polarity is rotating, the rotor polarity remains constant as in normal operations and the rotor turns as the stator polarity rotates. The inching rotation of the large motor can be reversed, and inching speed can be increased or decreased by manual control of the timing device. The 15-ton Shaw-Box overhead crane with the 5-ton auxiliary hoist, fills all other requirements on the grinding floor.

Grinding balls are hauled from the foundry in a special semi-trailer with low-hinged sides. The road at the ball bins, east of the No. 1 fine-ore bin, is so

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arranged that the trailer empties itself when the sides are unlatched. The ball bin is of concrete with a sloping bottom and with sections of 105, 105, and 40 tons capacity, respectively. The last section is for regrind balls.

From the ball bins the balls are hand-fed into 10-in. pipes and roll into a steel hopper located just inside the mill. From here they are fed as needed into 10 cu ft ball buckets, which in turn are carried by the 15-ton overhead crane to the platform at the ball mill scoop feeders. The balls drop into the ball-charging drum of the scoop feeders. The daily ration is weighed by means of a Hydroscale carried on the crane hook.

Flotation - The flotation equipment comprises 120 Fagergren 66-in. level-type cells, and 24 Denver 60 cu ft DR flotation cells divided into two 12-cell banks, all in two levels of 4 and 8 cells each; a cleaning section of 18 Fagergren 56-in. level-type cells in 3 banks of 6 cells; a scavenger bank of 12 Fagergren 66-in. cells, arranged in two levels of 4 and 8 cells; and two recleaner banks consisting of 6 No. 24 (43-in. x 43-in.) Denver "Sub-A" cells each. Two Whiting 5-ton overhead cranes serve this floor.

The flow sheet of the flotation section is shown in Fig. 3.

Pulp from the two 6-compartment distributors flows through 8-in. pipes to each of the 12 rougher banks. A 12-in. drop between the 4th and 5th cell in each 12-cell bank facilitates intermediate sampling and reagent addition, while also permitting a steeper slope of concentrate launders.

The rougher tailing of the last cell of all machines drops into a common tailing launder and is joined by the scavenger tailing.

The rougher concentrate flows to the pump floor and is pumped to a 26-ft. Hydroseparator for preliminary classification. The underflow is metered by two diaphragm pumps and split to the two regrind sections. Each regrind section consists of a 7-ft. dia. x 12-ft. Allis Chalmer overflow ball mill with trash trommel, a pair of centrifugal pumps (operating and standby), and a pair of 12-in. Krebs cyclones (operating and standby, or both if desired).

The hydroseparator underflow is pumped to the cyclones; the cyclone underflow enters the feed trunion of the ball mills; the ball-mill discharge passes through the trommel and into the pump box, there combining with the original feed to the regrind section and returning to the cyclones.

The overflows of the hydroseparator and the cyclones are dilute. The pipes, launders and boxes which carry these dilute pulps are so arranged that a part or all of each may be thickened before going to the cleaners, the balance going directly to the cells. This arrangement provides unlimited flexibility, since the quantity of water added in the rougher concentrate launders in the form of sprays, or for the purpose of obtaining optimum density of cyclone feed, can be changed over a wide range without producing adverse effects in the cleaners. Thickeming is done in a single 100-ft. thickener, which is adequate for all contingencies.

The underflow of the 100-ft. thickener is controlled with a diaphragm pump and then elevated to the cleaners by a centrifugal pump. The overflow goes to the reservoir.

The feed to the first cleaners, consisting of the cyclone overflow, part of the hydroseparator overflow, and the underflow of the 100-ft. thickener, is

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divided by a 3-compartment, rotating-type distributor among the three 6-cell 56-in. Fagergren machines. The concentrate from the first two cells on each bank can be combined directly with the recleaner concentrate as the grade of copper concentrate warrants. The recleaner concentrate is the feed to the molybdenite dextrin circuit. The recleaner tailing flows to the 100-ft thickener.

The first cleaner tailing is pumped to a "scavenger" bank of twelve 66-in. Fagergren cells. As a scavenger, it is expected to float out most of the recoverable copper from the cleaner tailing. The scavenger concentrate joins the rougher concentrate and is pumped to the regrind circuit. The scavenger tailing is sampled before it joins the rougher tailing, and then the joint tailing is sampled.

This practice of re-floating the cleaner tailing and rejecting it, in contrast to the conventional cyclic procedure, has the advantage of preventing an accumulation of activated, barren pyrite in the flotation circuit. By eliminating water, this procedure also helps to control the flotation time and the densities of the circuits.

MOLYBDENUM RECOVERY CIRCUIT

A separate paper by Mr. Clement Chase, metallurgist of the Silver Bell Unit, will cover this section of the plant, so the following description is simply a summary.

The final, bulk copper-molybdenum concentrate is thickened, conditioned with dextrin, and then floated to depress the molybdenum into a "dextrin" tailing amounting to 40 percent of the original concentrate. This enriched product is thickened and filtered, then heated in a multiple-hearth furnace to 500-600 deg F. The calcine is repulped and refloated, then cleaned and recleaned in seven stages, with a regrind after the second, to a final product assaying about 88 percent MoS_2 and less than 0.7 percent copper.

This flows to holding tanks, thence to a smaller disc filter discharging onto a storage floor. From here it is manually fed in 1000-lb batches to a vacuum, tumble dryer, and the dry concentrate from here is dropped into 55-gal steel drums for shipment.

Non-circulating rejects from the molybdenite flotation section comprise the final copper concentrate.

REAGENTS

Reagents are stored and prepared in a separate area north of the concentrator building. Facilities include a storage bin for pebble lime, agitated lime slurry tanks, creosote and pine oil storage tanks, and a reagent preparation building. The reagent building is a Steelox building 28 x 104 ft and is divided into three areas: pebble lime grinding, reagent solution preparation, and dry reagent storage.

Lime in pebble form is unloaded from truck hopper to a receiving bin and conveyed to a conical steel bin of 170 tons capacity. The lime is ground in a 5 x 6-ft Marcy ball mill. The ball mill discharges into a 4-ft Dorr FS rake classifier and rake product returns to the ball-mill feed. The lime slurry overflows the classifier and is pumped to two 18-ft dia. x 18-ft high steel tanks equipped with Dorr AP paddle agitators. From these storage tanks centrifugal pumps circulate the slurry through the concentrator and back to the agitator tanks.

Creosote and pine oil are transported from the railroad siding in a tank truck. Pine oil is pumped from a 7000-gallon tank into a 12,000-gallon tank and creosote added to make a 75 percent creosote - 25 percent pine oil mixture. From here a line carries a one-day supply to a head tank in the mill.

Souble reagents are stored in the reagent building and mixed as 8 to 15 percent solutions in 5-ft. diam. x 5-ft. high steel tanks. The solutions are pumped to day tanks in the mill. Milk of lime is fed to the primary mills, the regrind mills, the dextrin circuit, and the molybdenite calcine repulper through the lime loop. Xanthate Z-10 is fed to the primary ball mills, rougher circuit intermediate cells, and the scavenger bank feed. Pine oil-creosote mix is added to the primary ball mills only. Pine oil is used as a filtering aid at the copper concentrate filter. Dextrin is added at the head of the molybdenite circuit.

Superfloc 20 is added to the final tailings to aid the settling rate in the 275-ft. thickener; the points of addition are the hydroseparator overflow and the thickener feed-well. The dosage will vary from .005 to .01 lb. per ton.

CONCENTRATE HANDLING

The final copper concentrate consists of the dextrin cleaner concentrate (froth) and the molybdenite refloat tailing. The concentrate is automatically sampled in flow to the 60-ft. holding thickener at the filter plant. The thickener underflow is pumped to the 10-ft. x 12-ft. Peterson drum filter with a Denver SRL pump equipped with variable-speed drive. A hydroseal centrifugal pump is maintained for standby and for recirculating the thickener underflow when necessary. The filter is located on the top floor of a three-story steel building 32-ft. x 63-ft. x 34 ft. height. Concentrate is filtered at the

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rate of 15 tons per hour. An average daily production of 250 tons provides ample shutdown time for necessary repairs to the filter and auxiliary equipment. The concentrate thickener overflow is pumped to the 100-ft middling thickener overflow launder which flows directly to the 1,000,000-gallon reservoir. If additional settling time is required for casual losses of concentrate, the 60-ft thickener overflow can be fed directly to the 100-ft thickener. A Hazelton sump pump reclaims spills from a tunnel below the thickener and filter plant.

Filtered concentrate is conveyed to 20-ton end-dump semi-trailers and then hauled to Plata, Asarco's siding at the Southern Pacific main line near Rillito. At this point the trailers are emptied into a receiving hopper by means of a headframe and winch. The concentrate is conveyed into 100-ton bottom-dump cars, sampled, weighed on a Ferguson track scale, sprayed with American Cyanimid No. 52 binder, and hauled to Asarco's Hayden smelter.

TAILINGS DISPOSAL

Final tailing from the rougher and scavenger banks flows through 809 ft of 34 x 22-in. rubber-lined steel launders, slope 3/16 in. per foot, to a 30-ft hydroseparator and a 275-ft thickener. Most of the tailing material is diverted into the 275-ft traction thickener while the coarser particles are scalped off by launder gate and sent into the 30-ft hydroseparator. The overflow of the hydroseparator is fed into the 275-ft thickener. The underflows of both tanks are orifice-controlled at a concrete box conveniently located outside the thickener tunnel. From this box the thickener tailing flows through class 50, 16-in. dia. transite pipe laid on 0.7% grade to a concrete Y above the two tailing dams.

The tailing flows from the concrete Y through class 100, 16-in. dia. transite pipe which encircles the upper dam. One branch of the loop can be diverted to serve the lower, or new dam. The tailing can be deposited in either the upper or lower dam as needed. The tailing flows from the main 16-in. line through 4-in. spigots at 52-ft intervals.

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Each dam has its own decant line and collection pond. The upper collection pond has a diversion ditch which carries any overflow to the lower collection pond.

WATER

Water is pumped from three 500-ft wells in the valley 9 miles southeast of the concentrator. A 90,000-gal sand-settling tank receives water from the well pumps, and two radio-controlled booster pumps do the rest of the job, one located at the tank and the other 6 miles up the 18-in. line. The 18-in. pipe delivers to two 125,000-gal c ontrol tanks at the mill. The overflow of these tanks into the 275-ft thickener is makeup for the mill.

For townsite, firefighting, and all other requirements around the plant and the pits where fresh water is needed, a domestic tank holding 200,000 gal is located at elevation 2900 feet. This tank is filled by three 500-gpm pumps with a 1000-gpm pump on standby, drawing from the 125,000-gal control tanks. A pressure-break tank of 10,000-gal capacity for residential supply of domestic water may be bypassed in case of fire in the town.

The water is reclaimed from the mill pulps is accumulated in the 1,000,000-gal mill water reservoir west of the tailing thickener. This reclaimed water is made up of the overflow from the 100-ft thickeners and the tailing thickener and the water decant from the tailing disposal areas. The overflows of the thickeners are clear under normal operation, but some further sedimentation does occur in the reservoir, which must be cleaned periodically.

The decant lines are constructed of 18-in. transite pipe surrounded by reinforced concrete poured on bed rock. The decant water flows into one of two collection ponds through the 18-in. lines and is pumped to the mill water reservoir.

Mill water is then pumped from the reservoir to a 300,000-gallon head tank at elevation 2800 ft. using three Peerless Vertical closed-coupled turbine pumps, rated 3,000-gpm capacity each through 150-ft. static head. Electrode controls in the head tank start and stop the pumps successively.

POWER

Electrical power for the operation is generated by Tucson Gas, Electric Light and Power Company and transmitted 40 miles to Silver Bell at 43 kv. The mill substation is situated 160 ft. east of the concentrator and 12 ft. higher than the ball-mill floor. The high-voltage bus feeds through a 12,000 kva transformer supplying 4160 volts for the mill area and town, a 2200-kv transformer supplying 13,800 volts for the water pumps and El Tiro pit, and an isolating transformer supplying 4160 volts to the Oxide pit.

The power for the plant is carried from the substation at 4160 volts in buried cable to a distribution vault under the ball-mill floor. Motor voltages are 4160 and 440, the higher being used for motors of 200 hp or more. All secondary power is carried in underground conduits, keeping the plant area free of overhead cables.

A standby generator, 300 kw, 2400 volts, occupies a small prefabricated steel building in the substation. Storage batteries with trickle chargers are used throughout the plant for automatic emergency lighting.

AUXILIARY BUILDINGS

Attached to the mill at the east side and level with the flotation floor are laboratories for sample preparation and process testing, occupying 2760 sq. feet.

The filtering and drying room equipment includes pressure filters and electric dryers. The dry preparation section contains jaw and Gy-Rol crushers, pulverizers, screen grading devices, blenders, and cutting floor. The test laboratory is fully equipped for flotation work. An office for the metallurgical staff and an instrument repair shop complete the facilities.

Assay Office - Conveniently situated on the main east road, the assaying office is housed in a steelox 28 x 57-ft lined and insulated building with built-up roof and steel partitions. The laboratories include facilities for fire assay, electrolytic copper analysis, X-ray analysis, and other common analytical procedures.

Other large auxiliary buildings include two conventional steel buildings with galvanized corrugated steel roofing and siding. The first of these is a 52 x 182-ft machine shop housing carpenter, electrical, repair, welding, and rubber shops, and general mechanical repair areas. The other building is a 52 x 101-ft warehouse with office, shelving, storage bins, loading ramp and dock.

The smaller auxiliary buildings are prefabricated. These include a 28 x 43-ft change house, an oil and paint storage house, a twelve-vehicle garage, and a 28 x 68-ft first-aid building with a first-aid room, a meeting room, and a garage for the ambulance and fire truck.

The general office, of concrete block construction, completes the list of auxiliary buildings at the Silver Bell concentrator.

MATERIAL HANDLING

With the railroad siding 23 miles from the plant, trucks must bear the burden of supplying Silver Bell with most of its needs. At present the 23 miles are paved, but repairs are frequently necessary due to heavy summer rainfall.

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Many supplies travel all the way by truck from source to point of use at the mill; for example, balls, lime, acid, and reagents in drums. Others come in by rail and are transferred to trucks at the siding.

Facilities at the siding for transferring incoming freight are an American stiffleg derrick with 36-ft mast and 60-ft boom having capacity of 60 tons at an 18-ft radius, a car-puller, and a 200-gpm pump for unloading pine oil and creosote from tank cars to trucks.

Dependence upon truck transportation is reflected in the arrangement of the plant. Every building is easily accessible, roads are wide, and sufficient space between buildings rules out traffic jams and saves turn-around time. The work of mobile units, which includes winch trucks, front-end loaders, a truck-mounted P&H crane, and earth-moving equipment is facilitated by these intra-plant roads, unhampered by overhead power lines or low headroom caused by launders, conveyors, or pipe lines. The interiors of the main buildings are also readily accessible to trucks and other mobile units.

ACKNOWLEDGEMENTS

Grateful acknowledgement is made to Mr. Norman Weiss, whose original paper was used as a basis for this paper, and to the technical and administrative staff of Silver Bell, whose assistance is greatly appreciated in bringing this paper up to date.

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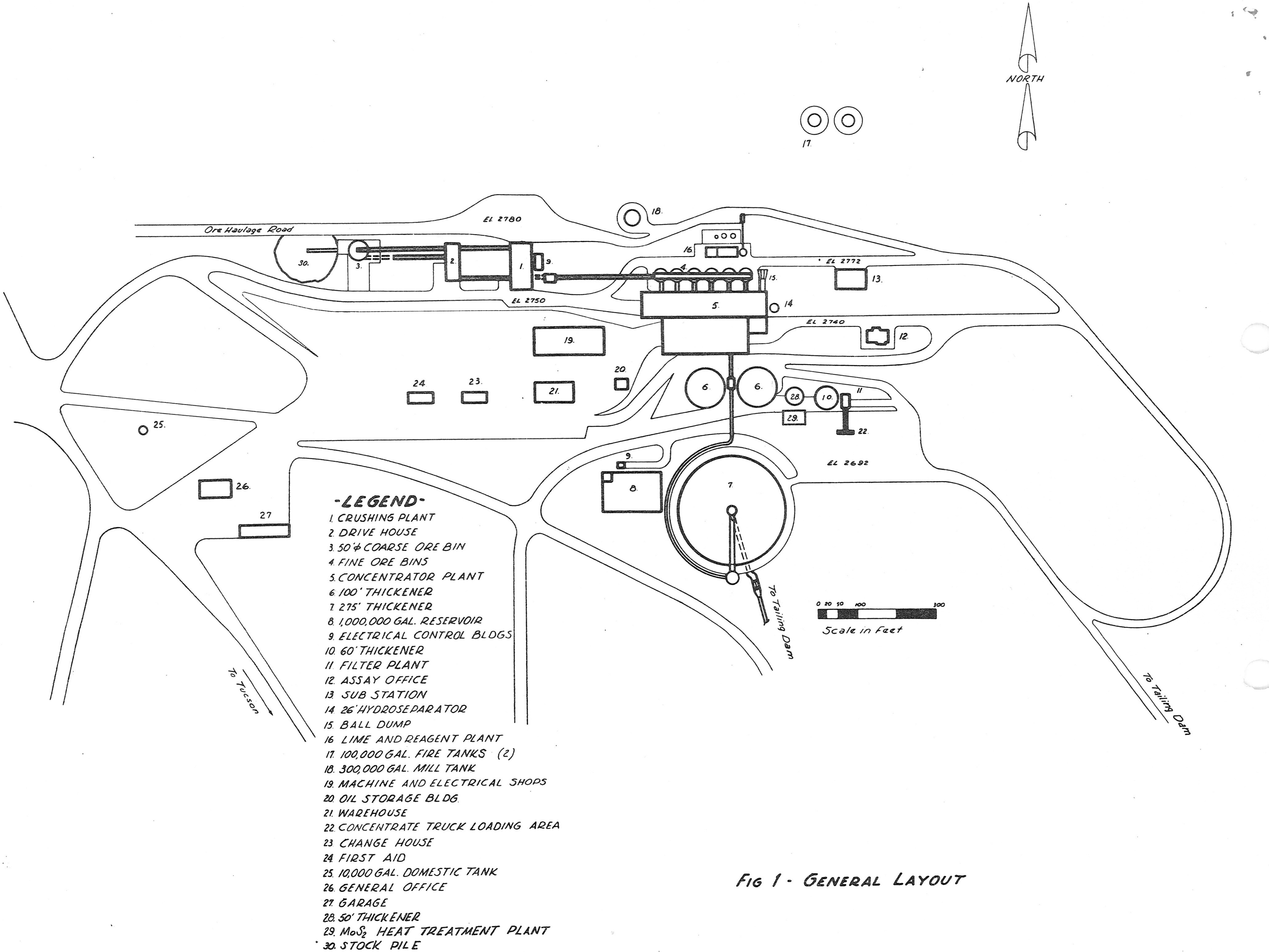
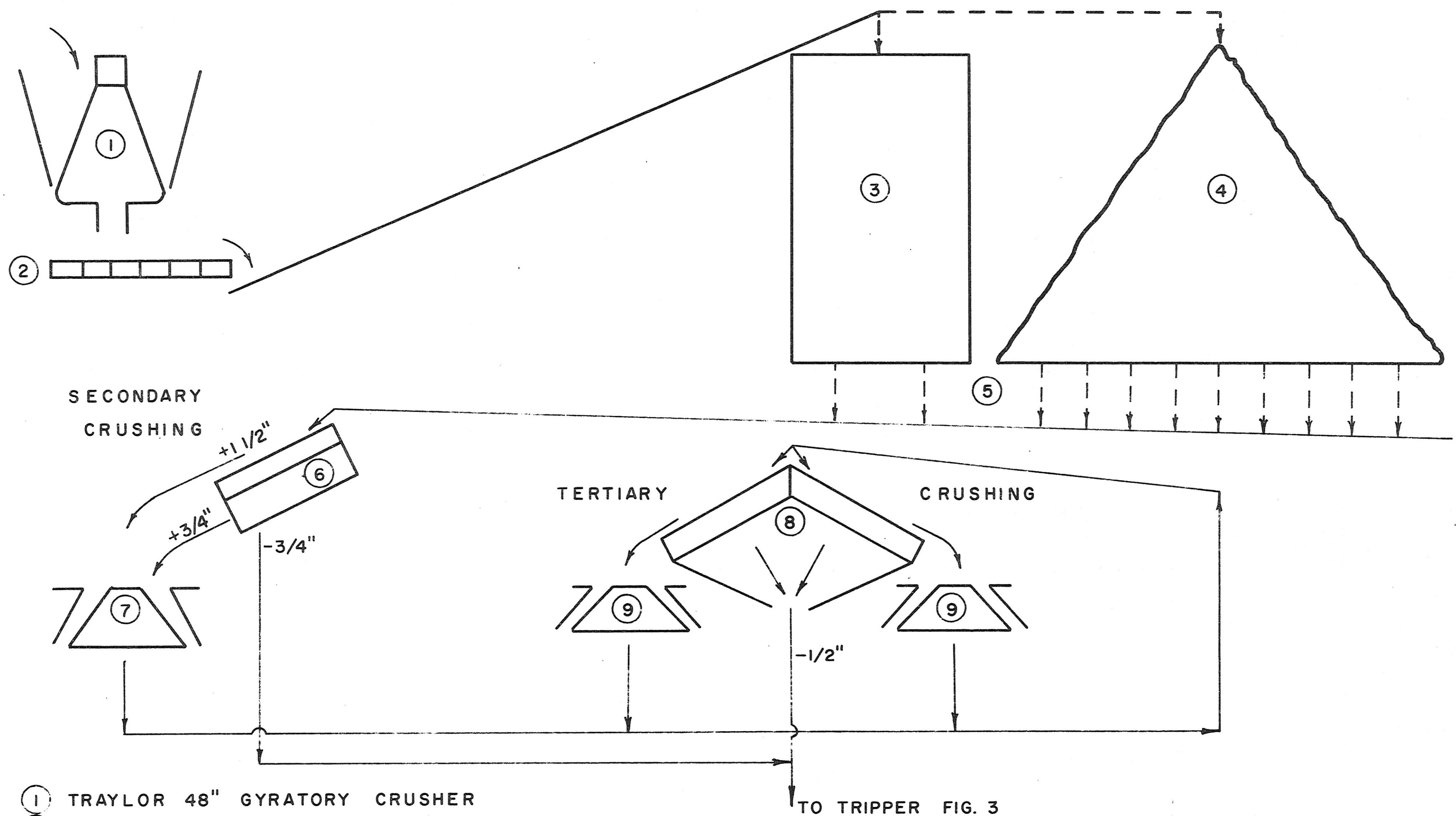


FIG 1 - GENERAL LAYOUT



1. TRAYLOR 48" GYRATORY CRUSHER
2. 6' X 20' PAN FEEDER
3. COARSE ORE BIN
4. COARSE ORE STOCKPILE
5. RECLAIMING FEEDERS
6. 6' X 12' ALLIS-CHALMERS DOUBLE-DECK VIBRATING SCREEN
7. SYMONS 7' STANDARD CONE CRUSHER
8. 4 TYLER 6' X 10' VIBRATING SCREENS
9. 2 SYMONS 7' SHORTHEAD CONE CRUSHERS

SILVER BELL FLOWSHEET

FIG. 2

CRUSHING PLANT

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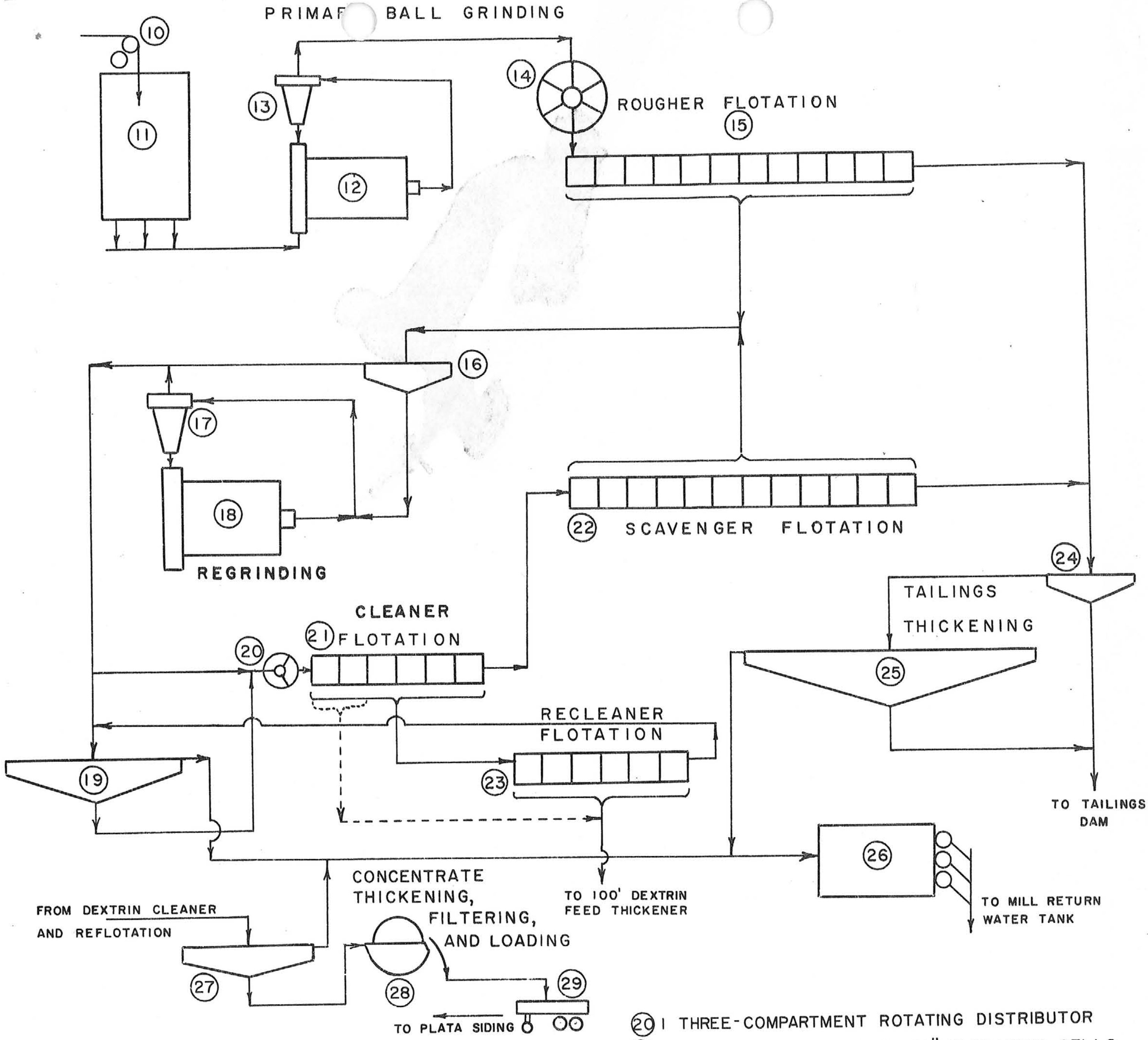

(10) MOVABLE TRIPPER
(11) 6 FINE ORE BINS
(12) 6 10-1/2' X 12' A-C GRATE BALL MILL
(13) 24 KREBS 20" CYCLONES
(14) 2 SIX-COMPARTMENT ROTATING DISTRIBUTORS
(15) 8 BANKS OF 12 FAGERGREN 66"
2 BANKS OF 12 FAGERGREN 60"
2 BANKS OF 12 DENVER DR. 60 CU. FT.
(16) ROUGHER CONC. HYDROSEPARATOR
(17) 2 KREBS 15" CYCLONES
(18) 2 7'X12' A-C BALL MILLS
(19) 100' DORR THICKENER

(20) 1 THREE-COMPARTMENT ROTATING DISTRIBUTOR
(21) 3 BANKS OF 6 FAGERGREN 56" FLOTATION CELLS
(22) 1 BANK OF 12 FAGERGREN 66" FLOTATION CELLS
(23) 2 BANKS OF 6 DENVER NO. 24 FLOTATION CELLS
(24) TAILINGS HYDROSEPARATOR
(25) 275' DORR THICKENER
(26) 1,000,000 GALLON RESERVOIR
(27) 60' DORR THICKENER
(28) 10'X12' PETERSON DRUM FILTER
(29) 6 CONCENTRATE TRAILERS

SILVER BELL FLOWSHEET

Fig. 3

COPPER CONCENTRATOR

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BY-PRODUCT MOLYBDENUM RECOVERY

AT SILVER BELL UNIT

AMERICAN SMELTING AND REFINING COMPANY

By

Clement K. Chase, Chief Metallurgist

Revised December 1966

BY-PRODUCT MOLYBDENUM RECOVERY AT SILVER BELL UNIT

AMERICAN SMELTING AND REFINING COMPANY

INTRODUCTION

The Silver Bell Unit of American Smelting and Refining Company is an open pit copper operation located forty miles northwest of Tucson in the Silver Bell Mountains.

Although Silver Bell is known primarily for copper production molybdenite is also produced as a by-product in the 11,500 ton-per-day flotation mill.

The Silver Bell ore comes from two pits approximately two miles apart. Copper mineralization is essentially chalcocite resulting from two to three-fold secondary enrichment in a highly altered zone. A typical porphyry copper deposit, Silver Bell ore is of medium hardness. The molybdenum occurs in the ratio of about one part molybdenum to seventy-five parts of copper. In the copper concentrate, which is the starting point for separate molybdenum recovery, the ratio is one part molybdenum to forty parts of copper.

Molybdenum mineralization is primary. Enrichment is not evident but it is notable that the molybdenite content is higher in the more siliceous, harder rocks. The mineral occurs as diversely oriented flakes of fairly constant grain size, mostly in fractures associated with quartz veins. Most of it appears unoxidized; secondary coatings on the molybdenite flakes are fortunately rare.

In May of 1962 a modification of the earlier molybdenite circuit was put into operation. This paper describes the new molybdenite plant.

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The metallurgical design and layout of the circuit was by Mr. A. B. Romney and Mr. Russell Salter under the direction of Mr. Norman Weiss. Detail design was handled by the Central Engineering Office of American Smelting and Refining Company, Salt Lake City, Utah. Construction was by Western Knapp Engineering Company of San Francisco, California.

THE SILVER BELL MOLYBDENITE CIRCUIT

Sulfide Copper Circuit:

The starting point for the molybdenite circuit is the cleaned copper concentrate, but a few words on the copper circuit are in order since this has a bearing on subsequent results.

The ore is ground with lime in ball mills and classified to 15% on 65 mesh and 50% minus 200 mesh in an all-cyclone circuit. Copper flotation collector is primarily potassium hexyl xanthate (Z-10) plus occasional auxiliary use of a dithiophosphoric salt collector (AF-238), and the frother is a mixture of 75% hardwood creosote-25% steam distilled pine oil. The copper rougher is in open circuit, rougher tailings being the greater portion of final tailings. The rougher concentrate is classified, the sands reground, and the combined sands and slimes cleaned twice with lime to attain the usual shipping grade of about 30% copper. The first cleaner tailing is scavenged, the scavenger tailing joining the final tailing and the scavenger concentrate joining the rougher concentrate.

Dextrin Depression of the Molybdenite:

The circuit is shown schematically in Figure 1. Copper concentrate is withdrawn from a 100 foot diameter thickener to a 6 ft. x 6 ft. open conditioner tank at the rate of about 195 TPD. Dextrin (either Stadex 120 or Clinton 761) in 12% solution is added at the approximate rate of one and one-half pounds per ton of concentrate, and make-up water is added from the 50-foot

C11

diameter thickener further down the circuit. The pulp is diluted to about 20% solids with this water (which contains some dextrin), and lime is added to the level of 0.2 pounds free CaO per ton of solution.

Next this slurry is fed to the molybdenite depression section, the first stage of which is a 30 foot long Miami-type air cell. Most of the copper floats here together with a small proportion of the molybdenite. To the froth from the air cell are added a half pound of dextrin per ton and a small amount of lime, in a bank of six #24 Denver Cells. The froth from this bank of cells is a final copper concentrate low in molybdenum and goes directly to the copper filter plant. The rougher and cleaner dextrin tailings containing the molybdenum are combined and sent to a 50 foot diameter thickener.

Since the combination of dextrin and high alkalinity from the lime produces a virtually non-settling pulp, acid is used to settle this material. The acid added modifies the pH from 11 to 8. The source of the acid used, both sulfurous and sulfuric, is the scrubber slurry from the dust collection system on the five-hearth furnace described below. Settling is adequate at this point.

Heating Step:

The thickener underflow is pumped to an 8 ft. x 8 ft. Eimco drum filter mounted directly on top of the 18-foot diameter Bartlett-Snow-Pacific five-hearth furnace fired by natural gas. The filter cake drops through a slot onto the top, or drying hearth, and proceeds downward by action of the rabble arms.

The furnace operates more as a drier than a roaster. Evolution of sulfur dioxide is not our objective, although some does occur as a result of the fall of fines from hearth to hearth through the flame areas. Retention time in the furnace was about four hours during initial operations but this

C10

has been reduced to 1-1/2 hours by increasing the number and length of the teeth on the rabble arms in the three upper hearths. The shaft speed was also increased from 2/3 to 1 RPM. The effect of these adjustments was to increase through-put while still maintaining satisfactory heating.

Measurement of hearth temperatures is accomplished through thermocouples indicating on an 8-point strip chart recorder. Final product temperature is 575 to 625 degrees Fahrenheit and it is important to keep it in this range since under-heating fails to destroy the dextrin coating with poor recovery and over-heating calcines the material with resultant high lime requirement and poor flotation conditions.

The furnace feed is occasionally wet and sticky. Under these conditions lumps can form and move through the furnace unbroken. Testing proved that the interior of such lumps can be under-heated, so two rollers were chained 180 degrees apart to the rabble arms on the middle hearth. Each roller is two feet in diameter by one foot wide. Constructed of 3/8" steel plate, they weigh about 250 pounds apiece and crush the lumps thoroughly.

The dust in the furnace gases is removed in a Doyle stainless steel wet scrubber. Installed between the exhaust fan and the stack, this unit scrubs out virtually all of the dust in the stack gases and the resulting slurry is returned to the thickener ahead of the furnace for recovery of the molybdenum and copper values.

<u>Reflotation of the Molybdenite:</u>

Hot calcine from the furnace drops through a chute into a 4 ft. x 5 ft. repulper tank and is slurried with fresh water. A normal roast will over-treat some fine particles and an acid repulp results. Since acid conditions here tend to activate copper and iron minerals that we want to depress, lime is added to the repulper under automatic control to maintain the pH near 7.

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Soda ash is also an effective alkali, but is more costly. Lime is fed from a branch line off the regular mill milk-of-lime loop to a supply tank in the molybdenite plant. This was necessary because the molybdenite plant is distant from the milk-of-lime loop and considerably lower in elevation.

Fuel oil is added to the repulper as a collector for molybdenite. Fuel oil and an alcohol frother are added at the head of the refloat section which consists of six #48 Agitair cells. These reagents may also be stage added along the cells. Emulsification and dispersion of the oil in the pulp is added by addition of 0.1% surfactant.

The original laboratory work showed refloat recoveries in the middle nineties. Plant operations have not been up to this level because of the effect of the circulating middling particles in the first, second, and third cleaner tailing streams. Effect of these return streams was not easily assessed in laboratory testing.

The effect of slime coating on dextrin depression and refloat of the molybdenite mineral is difficult to determine but we feel that they may be responsible in part for occasional sub-standard performances.

Cleaning Operation:

The refloat concentrate, containing minor amounts of copper and iron minerals, is cleaned twice in #36 Agitair cells without further reagent addition. The first cleaner tailing can be returned to the refloat or can be routed to the roaster or the final copper concentrate. The refloat concentrate, twice cleaned, is then ground in a 3 ft. x 4 ft. Marcy overflow ball mill. We now have this mill in open circuit after several years of struggle to keep a small cyclone in operation but better regrinding through classification and return of oversize to the regrind unit would be helpful at times. The reground concentrate is cleaned five more times in a counter-

C8

current cleaning circuit, with sodium cyanide and frother added to the final cleaner. The final product usually averages 51% Mo and less than 0.5% copper. Iron and insoluble commonly run about 3.5% each.

The third cleaner tailing was originally returned to the refloat stage but it soon became evident that the copper-cyanide complex anion was activating copper and iron minerals. Further testing established that this intermediate tailing should be returned to the furnace. This has been done but results in a long recycle path for a portion of the molybdenite.

<u>Filtering and Drying:</u>

Froth from the final cleaning stage runs by gravity to one of three holding tanks where it can be cyanide-leached, if required, to lower the copper content. This is seldom necessary. It is fed from the holding tanks to a three foot diameter, two-disc Eimco leaf filter. Filtered concentrate is held on the floor below in a surge pile whence it is charged into an enclosed Abbé rotary vacuum drier in 1000 pound batches. Discharge is by flexible tube into 55-gallon drums fitted with removable tops. Dust loss at this point is minimal, even though moisture averages only a half percent.

The circuit described above has not changed in any important respect since initial operation in May of 1962 but small mechanical improvements have been made from time to time which have made operations easier.

Some operating data appear in Table I. Also, a bibliography of literature of interest is appended.

SUMMARY

A considerable proportion of the molybdenite in the Silver Bell porphyry ore floats with the finished copper concentrate. This is the starting point for the molybdenite circuit, which includes the following steps:

1. Two-stage dextrin depression of the molybdenite into a product representing one-third of the copper concentrate tonnage.

2. Thickening, filtering, and heating of this fraction.

3. Reflotation of the molybdenite by addition of lime, fuel oil, and frother.

4. Seven-stage flotation cleaning with the addition of sodium cyanide to attain specification grade of molybdenite.

The following conclusions result from our experience with this circuit:

1. The dextrin circuit performs efficiently, concentrating most of the molybdenite into a fraction representing one-third of the copper concentrate weight, a dextrin coating on the molybdenite surface probably being the mechanism of depression.

2. Heating is a positive process to effect oxidation of the collector coating on the copper and iron mineral surfaces and, most importantly, to destroy the dextrin coating on the molybdenite surfaces so that the molybdenite can be re-floated.

3. Very satisfactory copper suppression in the final molybdenite concentrate is achieved in this operation.

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4. Production of a satisfactory concentrate from the Silver Bell igneous ores is generally independent of the copper mineralogy. Since parts of the ore body contain copper also as chalcopyrite although mineralization is primarily chalcocite, and the proportion of chalcopyrite may increase further in the future, the ability to recover molybdenite from both these copper minerals, and mixtures thereof, is important. Chalcopyrite in sedimentary ores at Silver Bell is a special problem for which circuit modification may soon be necessary.

5. The first three full years of operation of the new molybdenite circuit showed twice as much production as the average of the six preceding years. It should be noted, however, that the capacity of the mill was increased by 20% during the latter period.

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TABLE I

OPERATING DATA - SILVER BELL MOLYBDENITE PLANT

Reagent Consumption - Typical Year

Reagent	Pounds Consumed per ton of Copper Concentrate Treated
Dextrin	2.0
Lime	15.9
Fuel Oil	0.7
Frother	0.1
Sodium Cyanide	1.5

Regrind Balls, used, scrap	0.2 #/ton concentrate treated
Natural Gas	555 Cu ft./ton Conct. treated
Kilowatt Hours	29.9 per ton Conct. treated

Percent Mo Distribution - Typical Year

Mill Feed	100.0%
Molybdenite Concentrate	58.7%
Copper Concentrate	24.7%
Final Tailings	16.6%

In-Circuit Tonnage and Assays, Typical Day

Circuit	Approx. TPD	Approx. % Cu	Approx. % Mo
Dextrin Cleaner Feed	195	30	0.5
Dextrin Tailings (to furnace)	85	20	1.0
Copper Concentrate (to Cu Smelter)	110	35	0.1
Refloat Feed	100	14	1.6
Refloat Concentrate	15	14	9.0
Refloat Tailings	85	14	0.2
First Cleaner Tailings*	8.3	17	1.0
Second Cleaner Tailings*	4.4	15	5.0
Third Cleaner Tailings*	2.0	7	15.0
Final Molybdenite Concentrate	1.3	0.4	51.0

*These products are in circulation.

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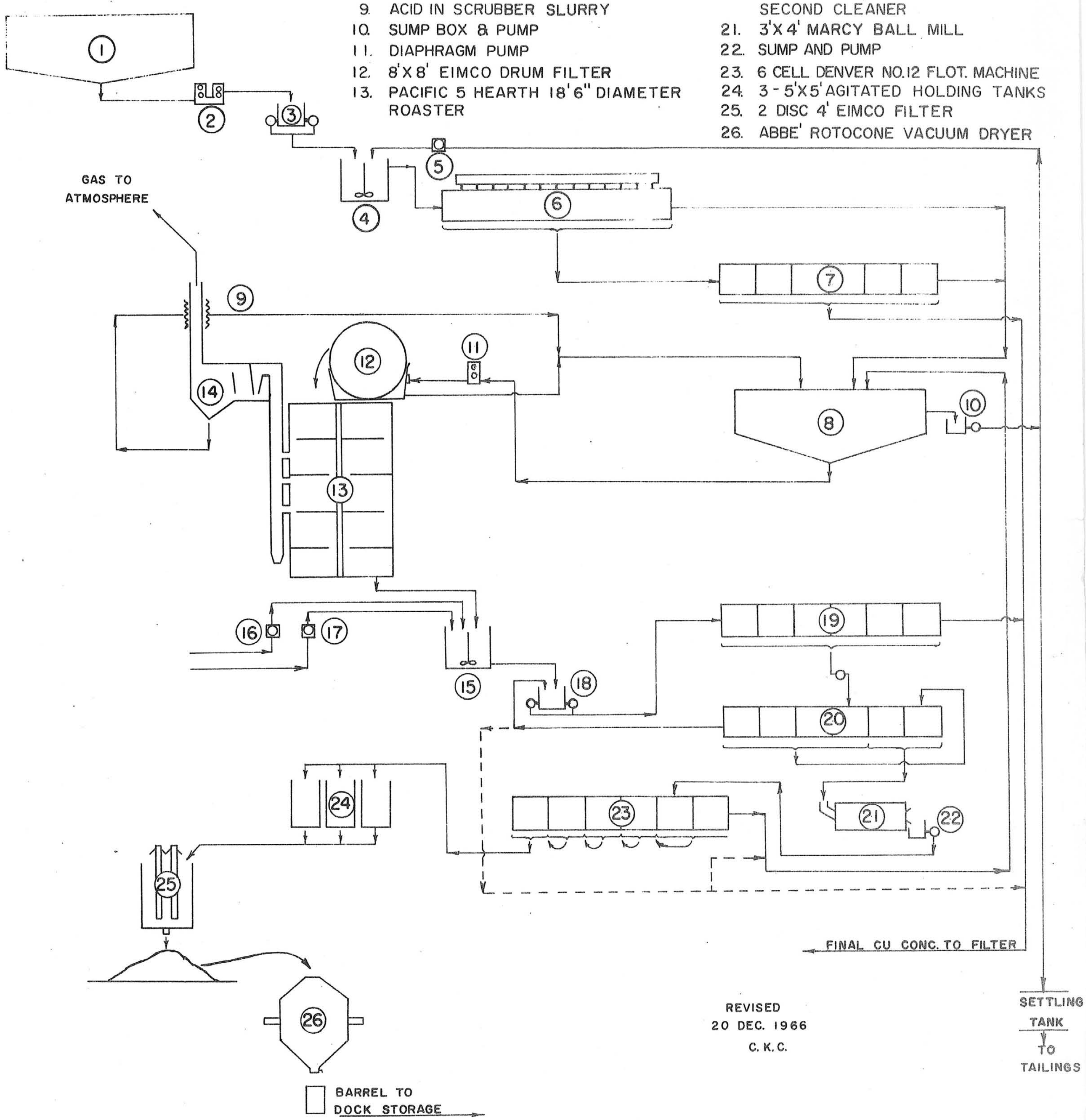
FIGURE 1

CLEMENT K. CHASE

1. 100' DORR THICKENER
2. DIAPHRAGM PUMP - NO. 6 DUPLEX
3. PUMP BOX & PUMPS
4. 6'X 6' CONDITIONER
5. AUTOMATIC DENSITY CONTROLLER
6. 30' AIR LIFT FLOTATION MACHINE
7. 6 CELL NO. 24 DENVER FLOTATION MACHINE
8. 50' DORR THICKENER
9. ACID IN SCRUBBER SLURRY
10. SUMP BOX & PUMP
11. DIAPHRAGM PUMP
12. 8'X 8' EIMCO DRUM FILTER
13. PACIFIC 5 HEARTH 18'6" DIAMETER ROASTER
14. TURBULAIRE WET SCRUBBER 16-T
15. 5'X 4' CONDITIONER
16. AUTOMATIC LIME CONTROLLER
17. AUTOMATIC DENSITY CONTROLLER
18. PUMP BOX & PUMPS
19. 6 CELL NO. 48 FLOTATION MACHINE
20. 6 CELL NO. 36 AGITAIR FLOTATION MACHINE, FIRST & SECOND CLEANER
21. 3'X 4' MARCY BALL MILL
22. SUMP AND PUMP
23. 6 CELL DENVER NO. 12 FLOT. MACHINE
24. 3 - 5'X 5' AGITATED HOLDING TANKS
25. 2 DISC 4' EIMCO FILTER
26. ABBE' ROTOCONE VACUUM DRYER



SILVER BELL MOLYBDENITE PLANT FLOW SHEET

C2

COPPER DUMP LEACHING AT ASARCO'S SILVER BELL UNIT, ARIZONA

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The Silver Bell Unit is an open-pit copper mining operation of the American Smelting and Refining Company, located at Silver Bell, Arizona, about 45 miles by highway west-northwest of Tucson. It comprises two open pits and a 7500 tons-per-day concentrator. Operations of the Oxide Pit and the concentrator began in March, 1954 (1). Mining of El Tiro Pit, located some four miles by road from the concentrator, began in the first quarter of 1955 A molybdenum recovery plant was added to the concentrator flow sheet in early 1957 (2) followed by the leaching plant, herein described, in January, 1960.

Geology and Mineralogy

The Oxide and El Tiro ore-bodies are typical porphyry copper deposits. The sulfide copper occurs principally as chalcocite in disseminated grains and in veinlets, with amounts of primary chalcopyrite (3). The major oxide copper mineral in the capping is chrysocolla, with minor amounts of azurite, malachite, and cuprite. Pyrite is a major sulfide mineral in the sulfide zone and is present, along with its weathered products, in varying quantities in the leached capping.

The ore-bodies are roughly tabular in form, varying from 100 to 200 feet in thickness. They are overlain by about 100 feet of leached capping which constitutes the major portion of the material segregated for the leach dumps. The line of demarcation between the oxidized capping and the sulfide zone is usually fairly distinct, with minor regions of mixed mineralization.

The host rock consists of three intrusives: alaskite, dacite porphyry, and monzonite. Sulfide mineralization, particularly chalcopyrite, occurred as disseminations and in fractures following the monzonite intrusion. The chalcocite ore-bodies resulted from the weathering and enrichment of the primary chalcopyrite.

The dumps now being leached are the result of selective mining during the stripping and active mining phases of the development of the two pits. Barren cap-rock is segregated and dumped separately in waste dumps. The copper bearing material in the leach dumps consists of oxide copper minerals and low grade sulfide copper minerals. Neither of these two classes of material could be profitably treated by flotation in the concentrator. The copper values are amenable to dump leaching in closed circuit with iron launder precipitation.

Dump Leaching - General Considerations

The name "Dump Leaching" is a rather generic term, covering a wide variety of operating characteristics. Historically, the present day practice might be considered to have started with the method of heap roasting followed by leaching as used in the Lower Harz of central Germany in the sixteenth century. Later this operation was revised and the pyrometallurgical phase replaced by slower but equally effective auto-oxidation in the dump leaching operations at Rio Tinto, Spain, starting about 1845 (4).

Or modern dump leaching might be considered as an offshoot of leaching in place which is applied to broken ore left in mined-out areas from previous underground mining operations. This also is an ancient method which found major application around 1850 (5).

In the southwestern United States, there are few copper ores as heavily pyritic as those of Rio Tinto, but there are quite large tonnages of lower grade material for which a cheap leaching method was long sought. Some of the first experiments and successful applications of dump leaching were conducted by the Phelps-Dodge Corporation at Bisbee, Arizona, and Tyrone, New Mexico, around 1920 (6). The Ohio Copper Company of Bingham, Utah, started its leaching in place operations in 1923 (7).

From this work and other experiments and applications by other mining companies, the necessary criteria for successful operation of dump leaching projects were determined and several such projects are now in production.

The more basic criteria for dump leaching are: (a) copper mineralization capable of dissolution in leaching solutions within reasonable lengths of time; (b) a host rock which will not consume inordinate quantities of acid, or decrepitate to prevent proper passage of solutions; and (c) a suitable site for placement of the dumps to insure minimal losses of pregnant solution to seepage and good drainage to a central recovery dam.

Additional advantages which are desirable, but not basically necessary are: (a) sufficient pyrite present in the dump material to generate enough free acid and ferric sulfate to dissolve the copper minerals without additional acid having to be added to the leaching solutions; and (b) not too much ferric sulfate produced in the dumps, which would make subsequent precipitation of the copper difficult or costly.

All the above basic criteria and additional advantages are realized in the dump leaching operations at Silver Bell.

Silver Bell Leaching Circuit

The basic leaching circuit (Fig. 1) starts with pumping a slightly acidic leaching solution to a leach dump and distributing it over the surface.

The solution then percolates down through the rock of the dump, extracting soluble copper salts. The pregnant solution from the dump is collected in a dam and pumped to precipitation cells where the copper is recovered as metal. The barren solution from the cells returns to a barren solution dam where a pump recycles it to the leach dump as leaching solution. Fresh water, used as make-up water to allow for losses due to soakage, seepage, and evaporation, is added with the cell tailings going to the barren solution dam.

Leach Dumps and Dams

At the present time, there are three dumps undergoing leaching (Fig. 2). The original dump, upon which the leaching plant started operations, is in a canyon adjacent to the Oxide Pit. This is now called the Upper Oxide Leach Dump. The ravine underlying this dump runs directly to the main pregnant solution dam near the precipitation cells.

The main pregnant solution dam (Fig. 3) is of concrete construction, abutting in solid rock on both walls of the canyon. It has a storage capacity of about 160,000 gallons.

The Lower Oxide Leach Dump was started in another ravine west of the Upper Dump. It has been formed mainly with leach material developed by stripping and mining after ore production for the concentrator was started in the Oxide Pit. In fact, leach material is still being added to its southwestern perimeter while the rest of the dump is being leached. The pregnant solution collecting in the ravine under the northern two-thirds of this dump is diverted with an earth-fill dam and a 16-inch pipeline some 250 feet long to the main pregnant solution dam.

The diversion dam has a 12-inch thick concrete key and the earth face is sealed and protected with gunite. The footings of this dam are in conglomerate but there has been very little leakage. The inlet to the diversion pipe is provided with slots for weir boards so the dam can be used as emergency storage of about 100,000 gallons of pregnant solution in case of trouble with the pumps at the main pregnant solution dam.

When the southern one-third of the Lower Dump is leached at some time in the future, it will drain to the same canyon as the Upper Dump and the solution will go directly to the main pregnant solution dam.

About 250 yards below the diversion dam and the pregnant solution dam the two ravines from the Oxide Dumps join as one. Below this junction another 50 yards lies the barren solution dam, another earth-fill dam with a tamped-earth key. The footings of the key are in solid rock on one side and donglomerate on the other. The storage capacity of this dam is roughly one and one-half million gallons.

From January, 1960, to April, 1961, only the Upper Oxide Dump was being leached. With the completion of the diversion dam and pipeline, all of the leaching solution was distributed on the Lower Dump. Since February, 1962, the Oxide leaching solution has been split in a drop-box into approximately equal proportions between the two Oxide dumps to allow better blending and control of the pregnant solutions.

In early 1961, the leach dumps being prepared adjacent to the El Tiro Pit were ready for leaching. In order to accomplish this, it was necessary to put in a pump and a pipeline from the barren solution dam to the

El Tiro Dumps, construct a dam across the canyon below, and provide pumps and a pregnant solution return line to the main pregnant solution dam. Also, the additional amount of copper to be precipitated required an increase in the number of cells and in drying area at the precipitation cells. Construction was completed and leaching started on the El Tiro Dumps in July, 1961.

The El Tiro Leach Dumps are laid out in four elevations, corresponding to the elevation of the pit floor as the leach material was being stripped. The lowest elevation, which also is the largest in area, is still actively being used for leach disposal along its northwestern perimeter. The three higher levels and a small corner of the lower level have been covered with solution and partially leached.

The El Tiro Dumps overlie four branches of a main canyon which drains the area. These four join under the dumps and there is only a single underflow. The pregnant solution dam is about 500 feet downstream from the toe of the dumps. It is of concrete, tied into solid rock and has a storage capacity of about 100,000 gallons.

There is an old mine shaft near the El Tiro Dumps which is used as an intermittent source of water at the rate of 20 to 100 GPM. This Daisy Shaft water is sometimes mixed with and sometimes applied separately from the barren solution to the El Tiro dumps. Use of this water replaces an equivalent amount of fresh water make-up needed at the barren solution dam. The Daisy Shaft water contains no significant amount of copper or acid since it has a pH of 6.5 to 7.0.

Leaching Solution Distribution

At the barren solution dam, there are two 6-inch vertical centrifugal pumps of type 304 stainless steel, driven by 100 H.P. motors, for pumping the solution to the dumps; one for the Oxide areas and one for El Tiro. They are floated on a raft to maintain constant submergence regardless of the rise and fall of the water level in the dam. The raft is made up of a wooden deck floating on 24 sealed ten-foot lengths of 12-inch I.D. PVC plastic pipe. The pumps are connected to their respective discharge lines by flexible hoses. The rate of the flow of barren solution from each of the pumps is measured and recorded by orifice plate meters.

The Oxide Dumps receive their leaching solution through a 10-inch pipeline approximately 4,000 feet long, with a static head of 250 feet. On the Upper Oxide, the solution is distributed from ten lateral pipes six inches in size. These laterals are provided with one and one-half inch plastic valves on each side of the pipe every 50 to 60 feet. These valves regulate the flow of solution to small, irregular ponds which average about 50 to 60 feet square.

When the Lower Oxide was being readied for leaching, it was decided to try a less elaborate method of distribution. In this system, the solution is simply delivered through an open-end 10-inch pipe to a high point and discharged to an open ditch. From the ditch, the solution is cut into one or more ponds as desired. This irrigation system has proven quite successful and the same method is now in use on the El Tiro Dumps.

One of the difficulties of operating a centralized precipitation plant with widely separated leaching areas is the long distances which the leaching solutions and pregnant solutions must be pumped to complete the circuit. El Tiro barren solution is delivered through three and one-half miles of 8-inch pipeline with a static head of 165 feet. From a discharge drop-box at the dumps, the solution is piped and ditched to irrigate the four terraced levels.

There are two 6-inch vertical centrifugal pumps of type 316 stainless steel to return the solution the three and one-half miles from the El Tiro pregnant solution dam to the main pregnant solution dam at the precipitation plant. They are driven by 50 H.P. motors and are pumping against a static head of 195 feet. An orifice plate meter measures and records the amount of solution pumped.

On all ponds, every effort is made to get the solution to spread out and cover as much area as possible and not short-circuit through the dump. In some rocky areas it has been necessary to bring in concentrator tailings to be spread in thin layers to reduce the porosity. The whole purpose is to gain as wide a distribution base as possible to get drop-by-drop penetration into the dump. This gives maximum expectation of wetting every rock in the dump, maximum contact time for leaching, minimum of channeling, and above all, a higher grade pregnant solution.

There is a practical limit, however, to these large pond areas, because of the high evaporation rate in the desert country which creates an appreciable loss of water. The per cent recovery of leaching solutions varies widely but averages 85 to 90 per cent. Most of the loss can be attributed to evaporation, with minor losses to seepage and soakage into the pores of the rock in the dump.

Chemical Reactions of Leaching

The chemical reactions involved in leaching of copper minerals have been thoroughly studied (8). The reader is referred to the original article for more complete coverage. From this source and others, the following overall reactions are given for the dissolution of the principal minerals involved in Silver Bell dump leaching.

Chrysocolla: $Cu\ SiO_3 \cdot 2H_2O + H_2SO_4 = Cu\ SO_4 + SiO_2 + 3H_2O$

Azurite: $Cu_3(OH)_2(CO_3)_2 + 3H_2SO_4 = 3CuSO_4 + 2CO_2 + 4H_2O$

Malachite: $Cu_2(OH)_2CO_3 + 2H_2SO_4 = 2CuSO_4 + CO_2 + 3H_2O$

Cuprite: $Cu_2O + H_2SO_4 + Fe_2(SO_4)_3 = 2CuSO_4 + 2FeSO_4 + H_2O$

Chalcocite: $Cu_2S + 2Fe_2(SO_4)_3 = 2CuSO_4 + 4FeSO_4 + S$

In vat leaching or agitated leaching, chalcopyrite is usually considered to be insoluble in leaching solutions or, at best, has a reaction requiring such an extremely long time that the amount dissolved is negligible. For these methods of leaching this is true. However, in dump leaching, time of reaction is measured in years. It is probable, then, that a small amount of chalcopyrite does dissolve slowly but inexorably over the years due to the action of ferric sulfate, oxygen, and water.

Chalcopyrite: $CuFeS_2 + 2Fe_2(SO_4)_3 + 2H_2O + 3O_2 = CuSO_4 + 5FeSO_4 + 2H_2SO_4$

At Silver Bell, no extra acid is added to the barren solution when it is pumped to the dumps as leaching solution. Experiments early in the operation of the plant indicated that extra acid addition was neither necessary nor particularly beneficial at this point in the circuit. The source of the sulfuric acid and ferric sulfate required by the above reactions is the reaction of pyrite in the dump with water and oxygen to form these solvents.

Pyrite: $4FeS_2 + 15\ O_2 + 2H_2O = 2Fe_2(SO_4)_3 + 2H_2SO_4$

Table I shows typical flow data and analyses of solutions to and from the dumps. Assays are reported in grams per liter. Note that the El Tiro pregnant solution return includes some 30 GPM of Daisy Shaft water addition on the dumps.

TABLE I

Dump Leaching Data

Barren Solution to Dumps

		Upper Oxide	Lower Oxide	El Tiro	Total
GPM		325	325	250	900
Cu	gms/liter				0.007
H_2SO_4	"				.06
Fe^{++}	"				1.67
Fe^{+++}	"				.04
pH					3.35

Pregnant Solution from Dumps

		Upper Oxide	Lower Oxide	El Tiro	Total
GPM		300	300	260	860
Cu	gms/liter	1.116	1.172	0.952	1.086
H_2SO_4	"	.56	.38	.24	-
Fe^{++}	"	.01	.01	.01	.01
Fe^{+++}	"	.50	.46	.78	.57
pH		2.36	2.40	2.43	-

As can be seen from the above data, the barren solution consists mainly of a slightly acidic solution of iron salts, most of which is in the ferrous form. In passing through the dumps, the pregnant solution has accumulated about one gram per liter of copper, gained in acidity at least fourfold, and converted its remaining iron content almost entirely to the ferric state. Some of the original iron content was precipitated in the distributing ponds and some in the dump itself. To date, there has been no indication that the iron precipitated in the dump may have a deleterious effect on percolation through the dump material.

Pregnant Solution Grade Control

The copper content of the pregnant solution underflow is maintained by gradual, progressive changes from one pond to another on the surface of the dumps. Usually, several small ponds are being leached at the same time. As the grade of copper in the underflow tends to fall, a new pond is cut in, and the pond which has been leaching the longest is cut out. The length of time during which a particular pond may be covered by solution varies from a few days up to several weeks. Since this time is dependent only on the copper being extracted, it follows that the depth of the leaching column, the copper content of the rock, the type of mineralization, and the efficiency of the leaching solution distribution are all factors in its determination.

After a pond is cut out of the leaching cycle and the excess solution has drained, the material in the leaching column underneath this pond will remain unwetted until the pond is again cut in for leaching in its turn in the progression from pond to pond to maintain copper grade. The time of this drying period varies from six months to a year at the present rate of operation.

During this drying period, there is still enough moisture in the rock to maintain the humid, oxidizing conditions required by several of the chemical reactions to create additional solvents and to dissolve the copper minerals. By diffusion, capillary action, and evaporation, these salts concentrate at the surface of the rocks and are readily dissolved by the leaching solutions during the next wetting cycle.

Precipitation of Copper from Solution

The solutions resulting from dump leaching are generally not very rich in copper. The range of copper assay in the solutions of several operating plants is from 0.5 to 2.5 grams per liter. Although there have been countless experiments conducted over the years to try to find a better way to recover copper from dilute solutions, none has yet supplanted the old method of precipitation on metallic iron. The chemistry of this reaction has been known for centuries and man has long recovered copper by this method from mine waters and solutions seeping from naturally-leaching copper deposits. References indicate that the process of cementation was put to commercial use at least as early as 1752 (4).

The first iron launders or cementation cells or precipitation cells, as they are variously called, were charged with pigs of iron as the precipitating medium. With the advent of greater industrial and household use of lighter gauge iron and steel, the pig iron was replaced by scrap iron. Later came the ubiquitous tin can which is now the standard precipitant in nearly all plants. Some still use locally gathered scrap iron as part of their precipitant to supplement the use of the more costly tin cans.

The main advantage of cans is the large surface area presented to the solutions per pound of metal. This large surface area promotes more efficient precipitation per unit of cell volume than with heavier pieces of iron.

Cans are prepared for use in precipitation by burning in kilns to remove the tin plating and paint from the surface, and the solder from the seams. After this, they are passed through a hammer mill or a toothed roll or some other shredder of suitable design to make them more compact and less bulky to handle, and less wasteful of space in the cells.

Untreated cans will weigh only 8 to 12 pounds per cubic foot. After shredding and compacting, they will weigh 20 to 30 pounds per cubic foot. The limiting factor of the compaction is that if it is carried too far, there will not be enough porosity remaining to get adequate solution penetration and efficient precipitation. Baled cans have never been widely used for this reason.

Chemical Reactions of Precipitation

There are three principal reactions taking place simultaneously in the iron launders. Only one of these is profitable. The other two represent a necessary operating loss to achieve the first; the precipitation of cement copper. The overall reactions are:

$$CuSO_4 + Fe = Cu + FeSO_4$$

$$H_2SO_4 + Fe = H_2 + FeSO_4$$

$$Fe_2(SO_4)_3 + Fe = 3FeSO_4$$

There is also a fourth reaction, between ferric sulfate and metallic copper, which undoubtedly takes place but yields the same net effect as the overall reactions given.

$$Fe_2(SO_4)_3 + Cu = CuSO_4 + 2FeSO_4$$

The copper sulfate formed in this reaction is reprecipitated on metallic iron as in the first equation. The overall effect is that at equal concentractions, the reduction of ferric iron to ferrous iron is the fastest of the three basic reactions. The reduction of copper is the next in rapidity, followed by the reaction between acid and iron.

Pregnant Solution Pumping to Cells

At the main pregnant solution dam there are two five-inch vertical centrifugal pumps of 316 stainless driven by 10 H.P. motors to pump the solution to the cells. A magnetic type flow meter in the discharge piping measures and records the rate and quantity of flow. The discharge pipe is ten inches in diameter, about 400 feet long from dam to cells.

The only sulfuric acid being added to the entire circuit at present is piped to the intake screens of the pregnant solution pumps. The amount of acid added is small; only enough to lower the pH to about 2.3. The purpose of this addition is to gain better copper precipitation conditions in the cells by preventing hydrolysis and precipitation of hydrous iron salts from the solution in the lower cells where the acid concentration is low.

Sulphuric acid is stored at the plant at 98 per cent strength in a 10,300 gallon storage tank and pumped to the pregnant solution dam by a variable-stroke diaphragm acid pump. Delivery to the plant is in a Company-owned 3,000 gallon semi-trailer, from an acid plant near Chandler, Arizona.

Cementation Cells

The original plant consisted of six precipitating cells. This number was increased to ten in 1961 to gain the needed capacity for the precipitation of the El Tiro solutions (Fig. 4).

Each cell is eight feet wide by five feet deep and is divided into two compartments, each twelve feet long, by a dividing center wall. The tops of the concrete walls are protected by six by ten timbers. At the five-foot depth in the cells is a perforated screen made of one-inch exterior grade plywood which has been locally drilled with three-quarter inch holes on one and one-half inch centers. The plywood screens are supported by type 316 stainless steel grids which have approximately two inch by four inch openings. The grids rest on two six by eight timbers which are keyed into the side walls in each compartment. Beneath this screen bottom, the concrete floor of the cells slopes to a twelve inch drain valve. This valve is operated by a bell crank and handwheel from the walkway on top of the cells.

An important feature of the design of the cells is that they are not all at the same elevation, but have a fourteen inch drop after each successive pair. This allows for adequate hydraulic gradient to assure free flow of solutions through the cells.

Cell Operation

Feed solution to the cells passes through Cells 1 and 2 in parallel flow from the feed launder and then returns, in parallel, back through Cells 3 and 4. The advantage of parallel flow on these first cells is that the heavy precipitation from the strong solutions is divided and there is less back-pressure or resistance built up to flow of solution. Beyond these cells, the solution passes in series through each cell. The discharge of Cell 10 is tailings solution which returns through a sump and a 16-inch pipeline to the barren solution dam by gravity.

In each cell (Fig. 5) the solution enters through a gateway from a launder into the upstream compartment. Most of the solution flows down through the cans in that compartment and through the holes in the screen bottom. It then passes under the center dividing wall, up through the screen bottom and through the cans in the second compartment before overflowing the discharge gate. Some of the solution will pass longitudinally through the top section of the cans in both compartments by way of the gateway in the center dividing wall.

Cans are delivered to the plant by side-dump semi-trailers. The loads are dumped off the side of a ramp about eight feet above the stockpile area. The cans are placed in piles by a diesel-driven crawler crane with a 65-foot boom and a five foot diameter electromagnet. The cans are transferred from the stockpile to the cells as needed, by the crane and magnet. Each magnet load of cans weighs about 460 pounds.

Table II shows typical precipitation cell data. Assays are reported in grams per liter.

TABLE II

Precipitation Cell Data

		Cell Feed	Cell Tailings
Cu	gm/liter	1.086	.006
H_2SO_4	"	.60	.08
Fe^{++}	"	.01	2.08
Fe^{+++}	"	.57	Tr
pH		2.30	3.60

Lbs. Acid per lb. Cu Pptd	.40
Lbs. Iron per lb. Cu Pptd	1.52
Man Shifts per Week	20

The above data illustrate the salient features of the precipitation cell operations. 99.45 per cent of the copper is stripped from the solution, the acid content is decreased, and the ferric iron content is reduced to ferrous iron.

A comparison of the cell tailings solution which returns to the barren solution dam with the barren solution being pumped to the dumps, shown in Table I, demonstrates that a considerable amount of the iron content is precipitated in the barren solution dam. This is advantageous in preventing an excessive build-up of iron in the leaching solutions. With the precipitation of iron, there is also a slight regeneration of acidity as indicated by the lower pH value of the barren solution.

Cell Washing

The first two cells always receive the strongest solution and must be washed the most often. They precipitate about 60 per cent of the total production and at present are being washed three times a week. The next pair, cells 3 and 4, make about 20 per cent more of the total and are washed once a week. Of the remaining cells, producing the remaining 20 per cent, cells 5 and 6 are washed every two weeks and cells 7, 8, 9, and 10 are washed once a month.

Situated below the ten drain valves from the cells are five settling tanks, each 16-feet, 10-inches square by four feet deep. When the cells are being washed, the slurry of copper precipitate and wash water flows to these tanks. After allowing time for the copper to settle, the clear water is decanted, and pumped by a three inch vertical centrifugal pump of 316 stainless from a recovery sump back to the cells to entrap any fine particles of copper.

When a cell is to be washed, wooden gates cut out the flow of solution, and the drain valve is opened to the settling tanks. The magnet transfers any loose cans which were not covered by solution to an adjoining cell. When the mass of copper and partially consumed cans is exposed, the copper is washed off the cans through the plywood screen bottom and out the drain valve. Washing is done with two one and one-half inch high pressure hoses equipped with quick shut-off fire nozzles. Water for washing is furnished from the tailings solution sump by a two and one-half inch vertical centrifugal pump of

316 stainless. Driven by a 3540 RPM, 25 H.P. motor, this pump can deliver 200 GPM to the wash hoses at 100 pounds pressure.

As the cans are washed clean, the magnet lifts them to the next cell. When the cell is empty, the screen bottoms are inspected and repaired, if needed. Average life of the screens is about four months in the first two cells; longer in the others. When repairs are complete, the washed cans are replaced, new cans are added, the drain valve is closed, and the gates are removed to put the cell back in the circuit. Ordinarily, a cell can be washed in about an hour and a half by two men on the hoses and one crane-man.

The operating crew consists of two operators, a helper, and a crane-man. All operations, from leaching solution distribution changes to cell washing, are performed on day shift only. Shift bosses from the concentrator check the plant on afternoon and night shifts to see that the pumps are running properly. The helper and crane-man work Monday through Friday but the two operators have different days off during the week and one or the other works alone on Saturday and Sunday day shifts.

Beside dump work and cell washing, the operators are responsible for sampling of the solutions, controlling the acid addition by pH measurements, and miscellaneous oiling and maintenance around the plant.

Precipitate Drying and Shipment

In order to reduce the weight of the cement copper shipped to the smelter and more importantly, to improve its handling characteristics, a drying pad of concrete has been provided on the opposite side of the settling tanks from the cells. The original pad was 35 feet by 105 feet and at times was not quite adequate for the amount of precipitate to be dried. With the extension for the El Tiro production, the present pad is 60 by 145 feet. Only the extremes of wet winter weather tax its drying capacity. Under those conditions, extra area would not help much anyway.

About once each week, the settling tanks which have copper in them from washing the cells are bailed out with the crane and a clamshell bucket. When first placed on the pad, the precipitate will contain 35 to 40 per cent moisture. It is placed in an irregular pile and allowed to drain for a day and a half. It is then picked up in small bucket-loads with a gasoline-driven front-end loader and laid out in rows about eight to ten inches deep. Occasionally, especially in the winter, there is further drainage of free water from these rows. The drying pad is sloped toward the settling tanks to help in the drainage.

The precipitate is left in rows for five more days in summer and up to 12 or more days in winter until the desired shipping consistency is reached. In winter, it is sometimes reworked with the loader to turn the material over and hasten the drying process. When dry enough, the precipitate is placed in a stockpile for ease of loading for shipment.

Carload lots of cement copper average 82 per cent copper and 15 per cent moisture.

The Company railroad siding is a spur off the Southern Pacific mainline at Plata, near the Tucson-Casa Grande Highway, a distance of 23 miles from Silver Bell. The same trucks and trailers which haul the concentrates from the mill are used to haul the precipitates to the siding. Usually three trailers, each hauling 35,000 to 40,000 pounds of precipitate, are sufficient to fill a carload. At the siding, the end-dump trailers are unloaded by means of a head-frame and winch into a hopper. From there, conveyor belts deliver the material to open gondolas. The loaded cars are sampled for moisture and copper assay, weighed, and sent to ASARCO's Smelter at El Paso.

Conclusion

The dump leaching project is an efficient adjunct of the Silver Bell Unit. It provides a method for recovering the copper values from a low-grade material which would not be amenable to treatment in the concentrator.

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7. Hayward, Carle R.: An Outline of Metallurgical Practice, D. Van Nostrand Co., New York, 1946.

8. Sullivan, John D.: Factors Involved in the Heap Leaching of Copper Ores, U. S. Bur. Mines Circ. 6425, April, 1931.

Attachments

Fig. 1. Flow Sheet of dump leaching circuit.

Fig. 2. Map of Silver Bell District showing relation of leach dumps and precipitation plant with Oxide and El Tiro Pits and concentrator.

Fig. 3. Layout of precipitation plant, showing pregnant solution dam, diversion dam, barren solution dam, cementation cells, settling tanks, drying pad and storage area.

Fig. 4. Plan view of precipitation cells, showing direction of solution flow, and front elevation, showing elevation drop between cell pairs.

Fig. 5. Cross-section view of a cell, showing solution flow through individual cell, and cell relation to settling tank and drying pad.

FIGURE 1

FLOW SHEET-DUMP LEACHING CIRCUIT

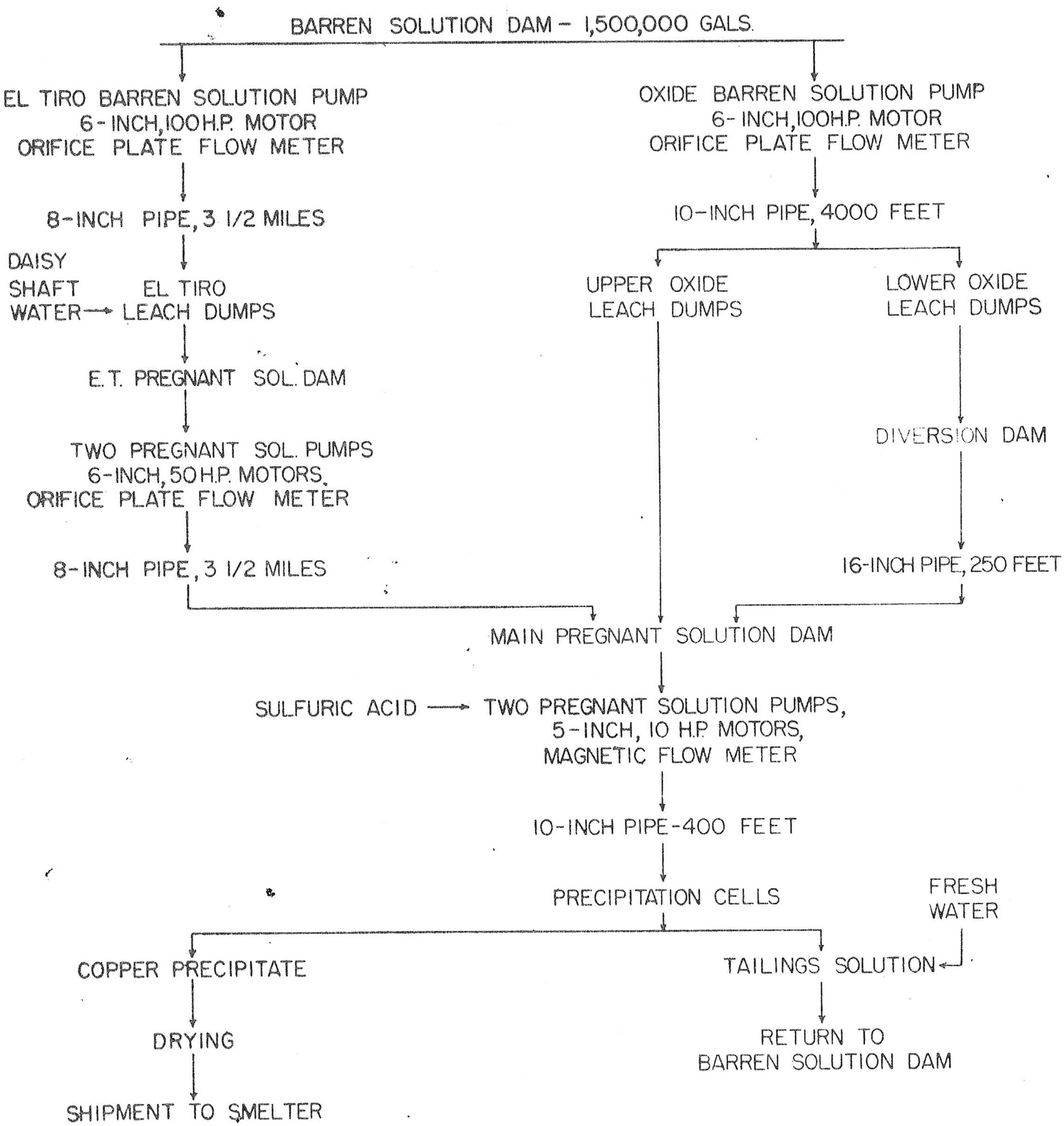
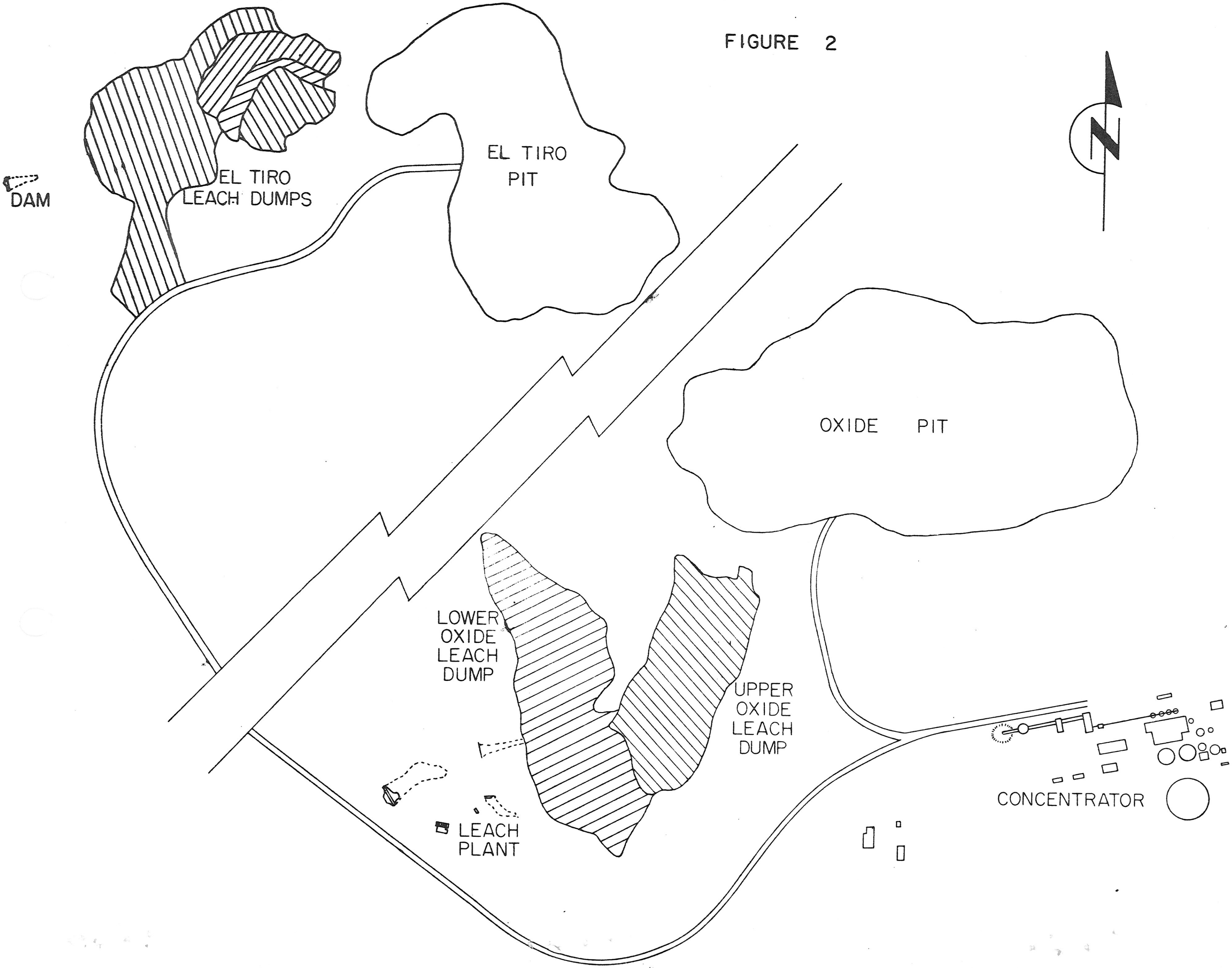


FIGURE 2


DAM
EL TIRO
LEACH DUMPS
EL TIRO
PIT
OXIDE PIT
LOWER
OXIDE
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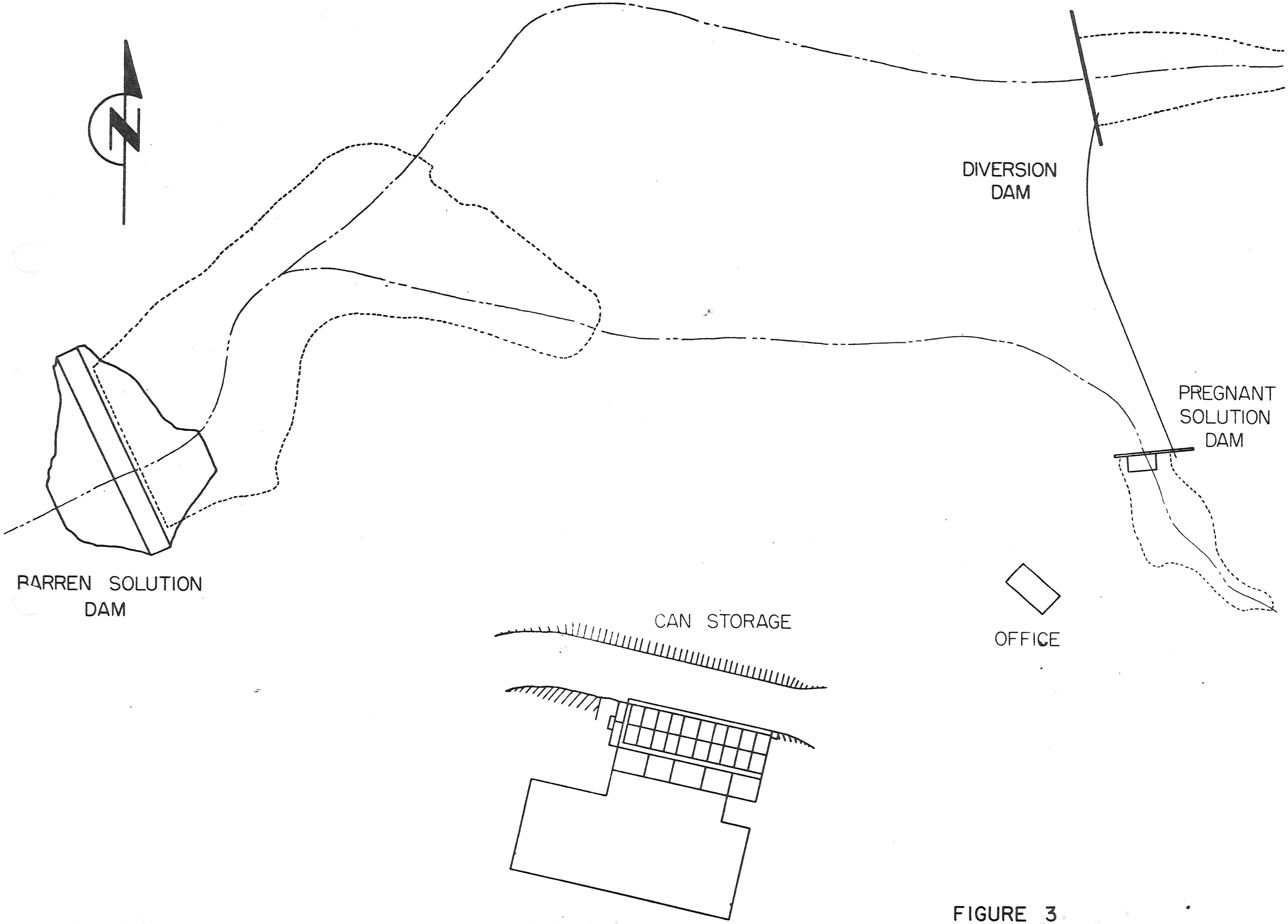
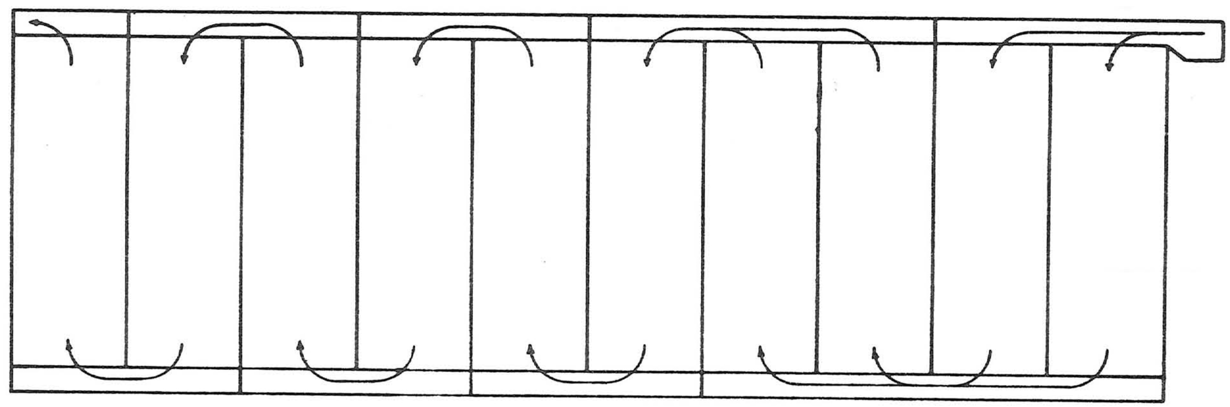
PLANT
CONCENTRATOR



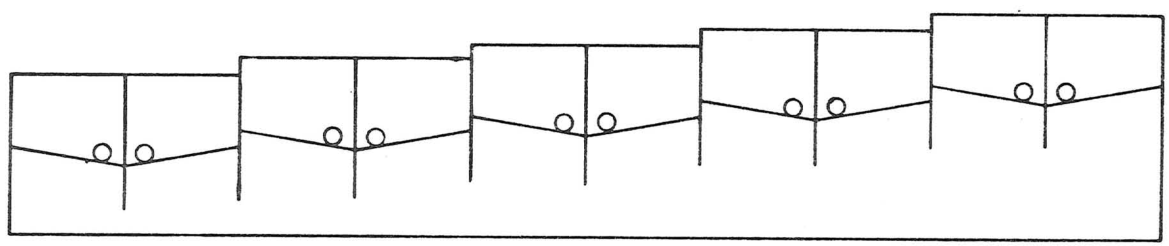
DIVERSION DAM
PREGNANT SOLUTION DAM
BARREN SOLUTION DAM
CAN STORAGE
OFFICE

FIGURE 3

FIGURE 4



PLAN



FRONT ELEVATION

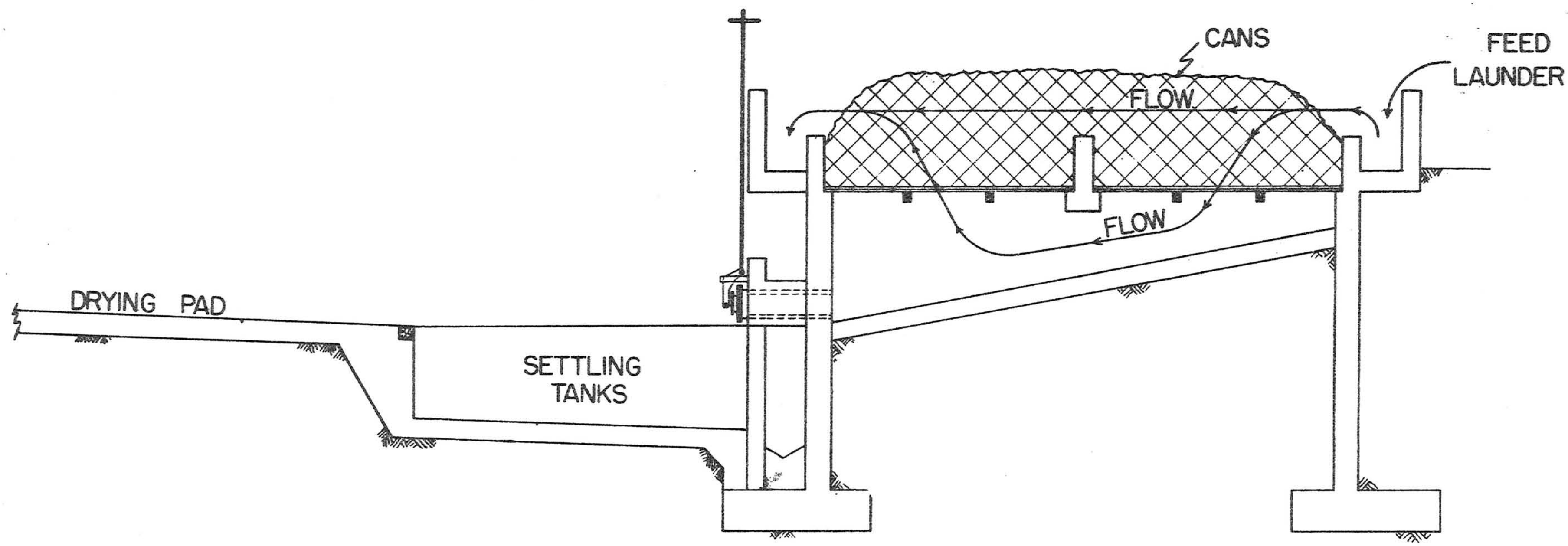
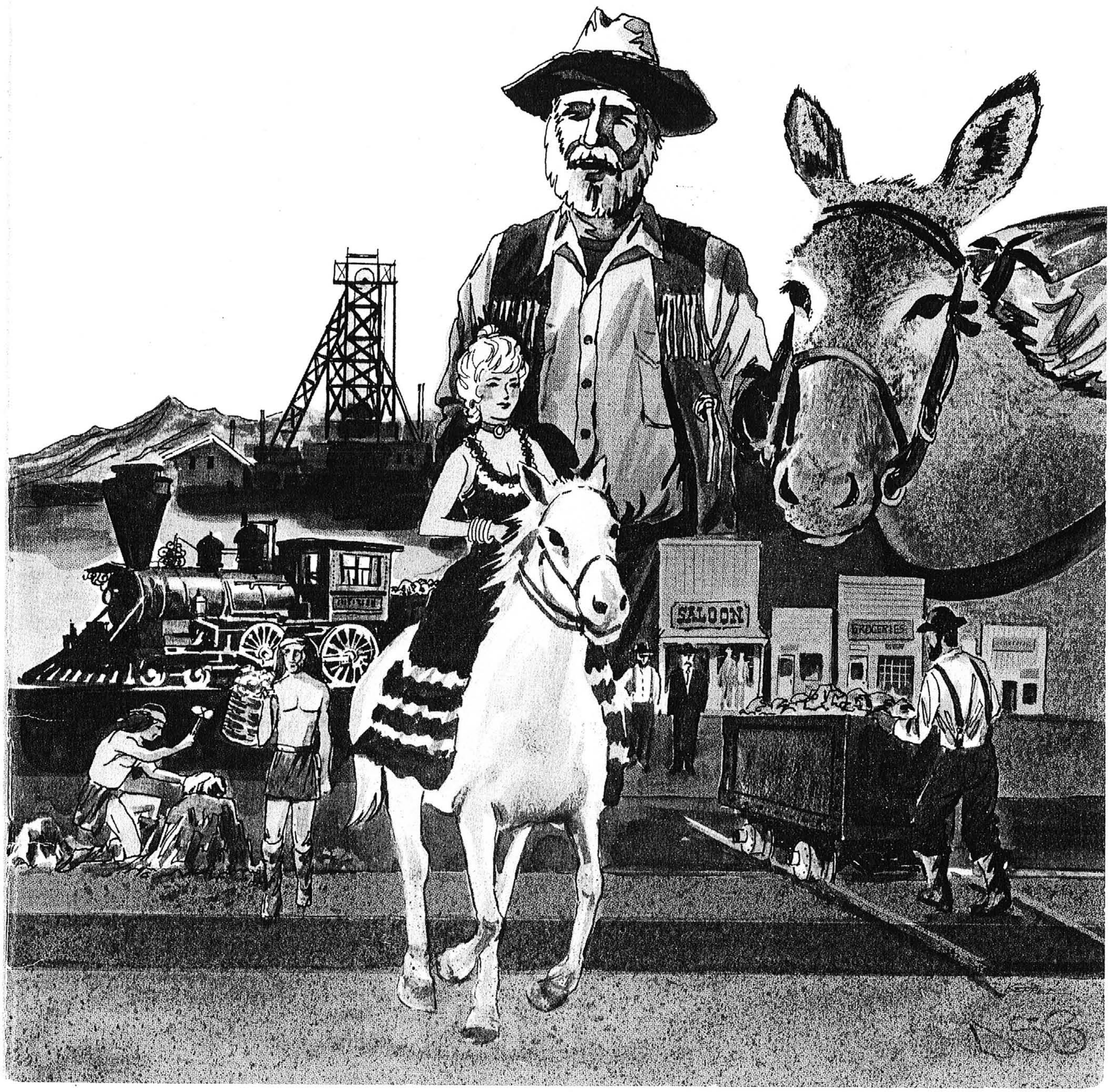


FIGURE 5

ASARCO

SILVER BELL MINE



The History of Silver Bell or the Taming of the Toughest Town in Pima County!

The name Silver Bell conjures up visions of things delicate and beautiful. Don't let it! As late as January 12th, 1908, the Tucson Citizen newspaper noted that this prosperous mining town was weary of being known as the toughest town in Pima County "where hell breaks forth every pay day." There was a time when Silver Bell rivaled or even surpassed Tombstone, "the town too tough to die," in orneriness. Indeed, it was called "the hell hole of Arizona."

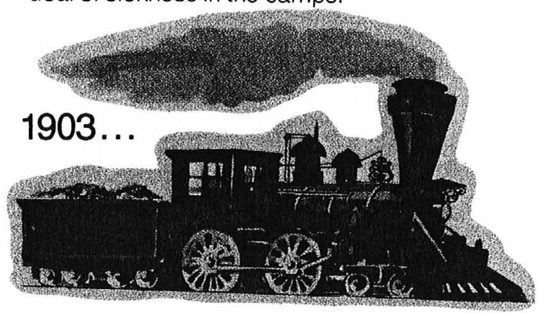
The naming of Silver Bell

With such a dubious reputation, how did Silver Bell acquire its lovely name? No one knows for sure. Some say it comes from a desert flower; others claim it's the namesake of Belle Carruthers, a lady of the Old West often seen riding through town on a silver horse; still another story tells of an awesomely beautiful dance hall girl named Belle whose hair turned prematurely grey. We'll probably never really know which story is closest to the truth (if any of them!) because no one is quite sure when Silver Bell was born. But few mines have an older or livelier history than this one!

Its first years

The names of its first prospectors are unknown. There are reports of the general area being worked by Spanish padres seeking copper and silver sometime in the 1700s. In the early 1860s, a few mining sites were excavated, but the metal content was too low and transportation too difficult and costly to make mining profitable. However, in about 1865, higher grade oxidized copper ore was selectively mined and hauled from the district by wagon.

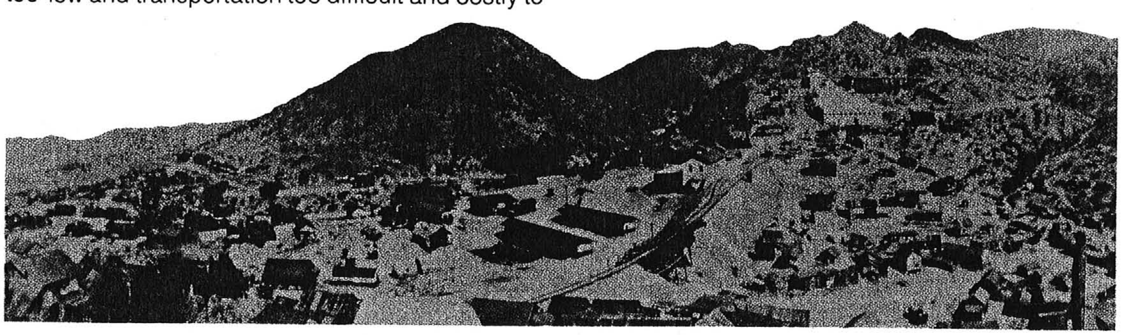
In the 1880s, teams loaded with lumber, merchandise and supplies were constantly arriving, and the influx of prospectors and would-be investors continually increased. But lack of water was always a problem and transportation costs were high. Miners suffered terribly from the heat and there was a great deal of sickness in the camps.

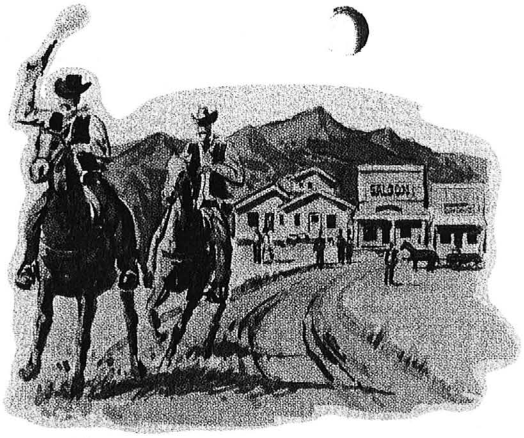


In 1903, the Imperial Copper Company started a new townsite with shacks, tents and lean-tos. The Southern Arizona Railroad built a rail-line connecting the Southern Pacific main line at Red Rock with the mines at Silver Bell in 1904. The town grew to a population of about 1000, and included: one grocery store, two saloons, a dairy, a justice of the peace and a notary public. The Silver Bell Post Office was established on August 8th of that same year.

The years 1906 and 1907 were boom years for Silver Bell. Optimism ran high. So did lawlessness, greed, drunken brawls, stabbings and killings. Doctor Mead Clyne, who supervised the doctors at Silver Bell, had a small glass jar over half full of lead bullets that had been removed from various "patients" in Silver Bell.

In 1911, a bad shaft fire at Silver Bell, low copper prices, and a shortage of water at other properties





caused the Development Company of America to go bankrupt and cease operations at its Imperial Copper Company subsidiary in Silver Bell. This was a blow to the camp; the only businesses to survive were a grocery store and a saloon.

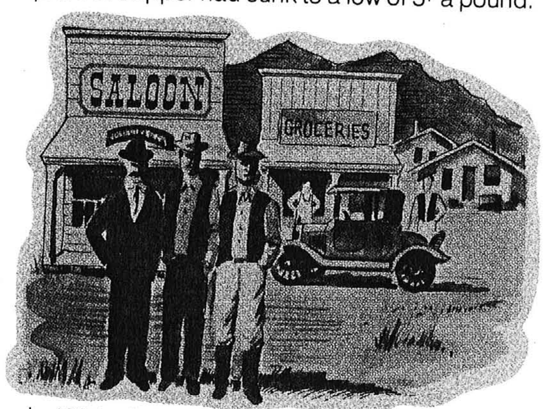
Asarco

In 1915, the American Smelting and Refining Company (now known as ASARCO Incorporated) acquired the Imperial Copper Company. The properties were operated by underground methods during the First World War. Silver Bell grew to a town of over 1200 and boasted the advantages of having both a school and a hospital.

But the good years were short ones. In 1921, the price of copper dropped dramatically and so did production.

The 30s

With low copper prices continuing through the roaring twenties and into the Great Depression, Silver Bell almost became a ghost town. The population dropped from 500 in 1930 to 45 in 1931. By 1932, the price of copper had sunk to a low of 5¢ a pound.



In 1934, all the machinery and equipment at the Imperial Copper Smelter, plus the rails to Red Rock, were dismantled and sold for junk.

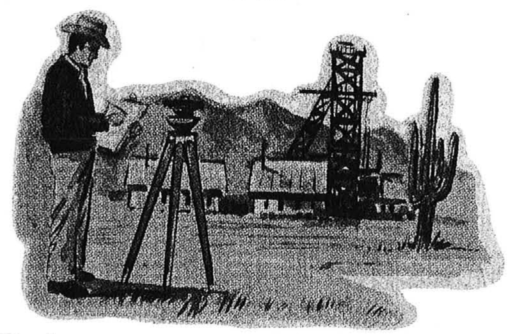
The ghost of Silver Bell haunted the territory. But Silver Bell refused to die, and once again copper prices began to ascend.

The 40s and 50s

In 1940, Asarco acquired additional property and brought the major portion of the district under the control of one company. With the increase in copper prices and the advances in engineering methods and equipment, large low-grade ore deposits became of economic interest.

In 1946, Asarco undertook an extensive geologic exploration and churn drilling program to check former drilling. Detailed plans were made to mine these deposits by modern open-pit methods. The outbreak of the Korean War brought U.S. Government inducements to increase output of copper.

Initial stripping was started in December, 1951. Construction of the concentrator was begun in February of 1952. The first ore was processed in March of 1954. Operations have continued ever since. A new town was established about four miles southeast of the Old Silver Bell townsite.



Today

Today's Silver Bell has a population of approximately 800. There are 175 houses, 30 trailer spaces, 24 apartments and 20 bunkhouse rooms. If the ghost of Silver Bell were to walk its streets today, it would enjoy the pleasures of a general store, post office, recreation hall, barber and beauty shop, swimming pool, baseball diamond, tennis and basketball courts. Asarco employs over 300 workers, one-third of whom live outside Silver Bell in surrounding areas and in Tucson.

It is a pretty setting for a town with a pretty name. In the short years since its establishment trees, flowers and shrubbery have softened Silver Bell's residential contours. Silver Bell now is a quiet, peaceful community. The "hell hole of Arizona" exists only in its legendary history.

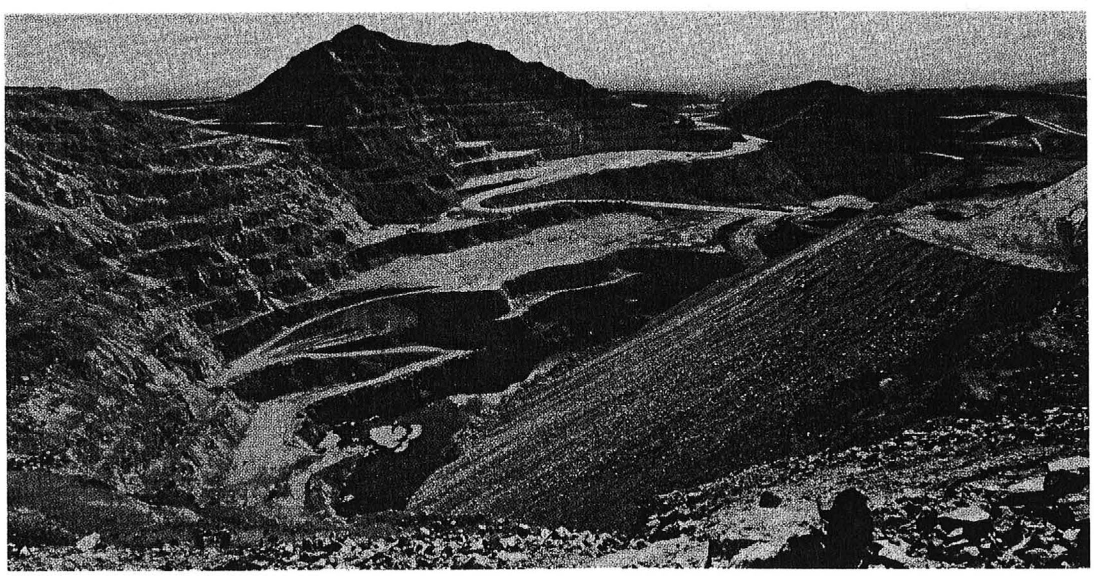
The copper Asarco is mining today had its beginnings 75 million years ago!

The Silver Bell deposit is located along the northwest-trending Silver Bell Fault Zone, which served as a channelway for the intrusion by igneous rocks 75 million years ago. Violent volcanic activity caused thick layers of volcanic debris and large chambers of magma to accumulate at great depths beneath the surface. Copper-rich fluids were ejected from the magma as it solidified. The fluids were then guided upward along the Silver Bell Fault Zone and toward the tops of the magma chambers. As the fluids pushed toward the surface, they produced an intense network of fractures into which the copper minerals were deposited. Silver Bell's Oxide and El Tiro pits are on sites which accumulated higher values of copper mineralization. Extensive erosion of the volcanic debris exposed the solidified magma and copper minerals on the surface. Surface weathering conditions resulted in redeposition of the copper as chalcocite. The formation of chalcocite made it economically feasible to mine copper at Silver Bell.

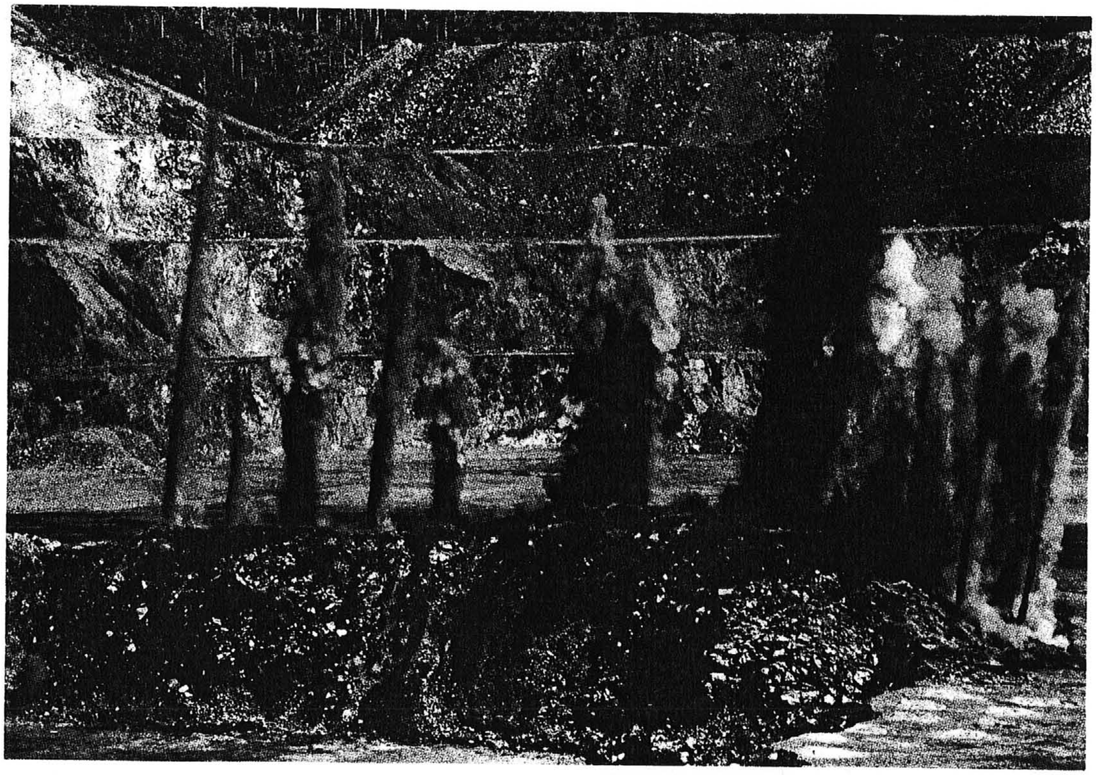
The lay of the land

Asarco's Silver Bell property lies to the west of Arizona's broad Avra Valley (bottom photo). The land slopes gently for nine miles from the valley floor, at elevation 2020 feet, up to the town of Silver Bell. The mill site is 100 feet higher than the town, and at this point the grade increases sharply to a ridge of 3315 feet which stands as a natural curtain between the Oxide pit and the plant.

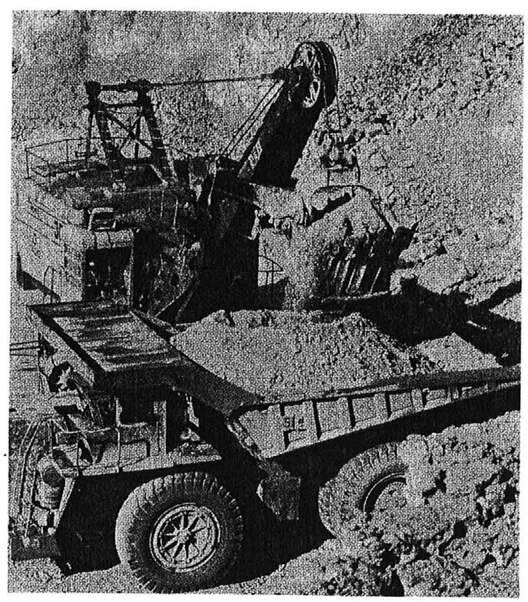
Silver Bell's two ore bodies are separated by two and one-half miles. The El Tiro pit is approximately one mile long and one-half mile wide. The pit is laid out in 40 foot benches, with haulage roads throughout. The Oxide pit is approximately three-quarters of a mile long and one-half mile wide.



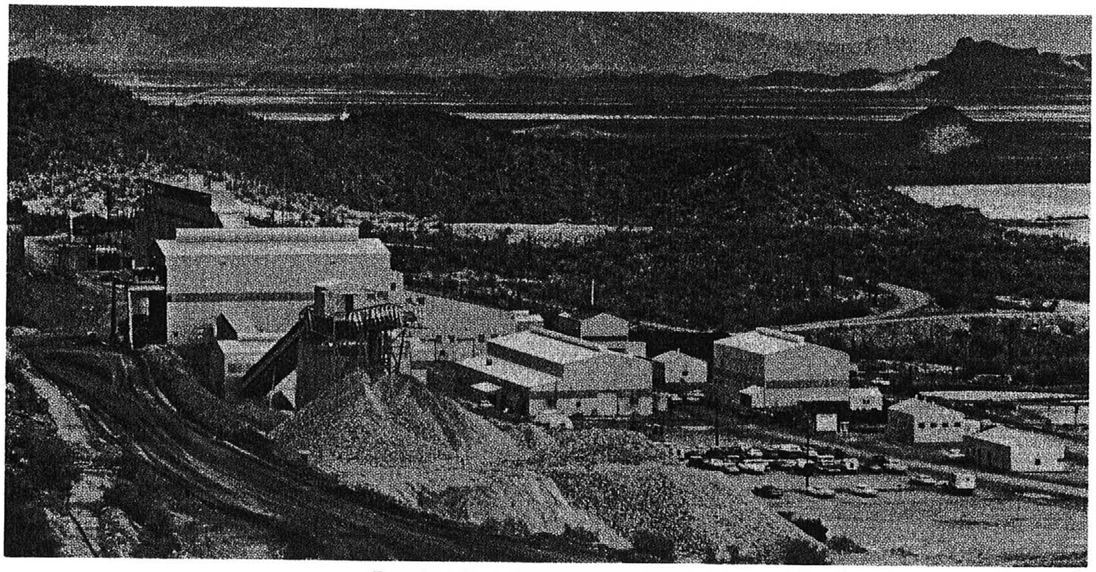
Blasting and Mining



Blasting (above) frees the ore, which is loaded onto large ore haulers (bottom right) to be taken to the crusher. There are 23 trucks at Silver Bell with hauling capacities of 75 tons. Loading equipment includes 4 five-yard shovels, 1 seven-yard shovel and 2 fifteen-yard front-end loaders.



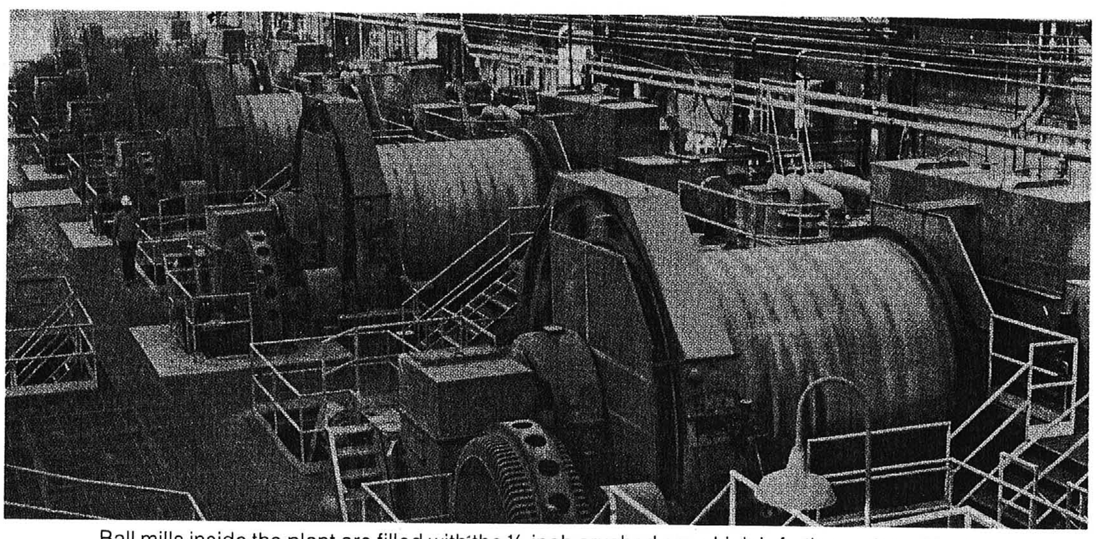
Milling



Exterior view of the Silver Bell Plant.

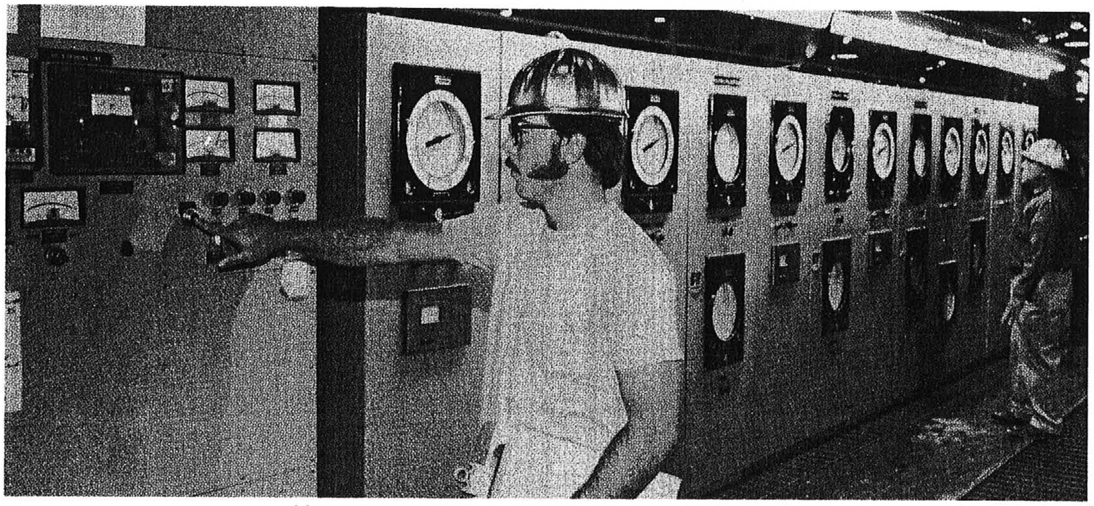
The arrangement of the milling facilities provides efficient operation because of the simplicity and compactness of design. Closed circuit crushing is employed to crush 11,400 tons per day of pit ore to ball mill feed size.

The ore is dumped into the primary crusher, where it is reduced to 6 inches. Secondary and tertiary crushing equipment reduces the ball mill feed.



Ball mills inside the plant are filled with the ½ inch crushed ore which is further reduced in size.

The crushing plant was designed originally for 1,000 tons per hour in the primary section and 500 tons per hour in the secondary and tertiary sections in closed-circuit operation. In a 1965–66 expansion program, the secondary and tertiary sections were increased to 600 tons per hour.



Men at the control panel inspect the interlock system.

An electrical interlock system (top) is arranged so that stopping any machine will automatically stop all ore-carrying equipment preceding it.

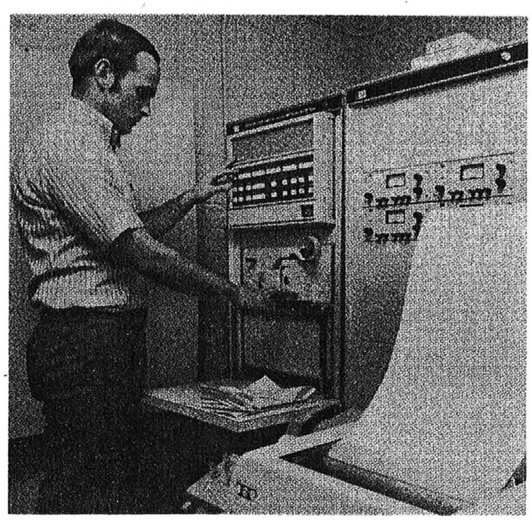
Failure of a lubrication system automatically causes shutdown of the corresponding crusher.

An inter-communication system with stations at strategic points saves the operators many steps. Closed-circuit TV stations are situated on the primary observation floor and on the Symons crusher operating floor. From here the operator watches ore loading and transfer at several critical points in the conveyor system.

During the crushing operation, special provision has been made to draw off the dust-laden air by both wet and dry dust collectors. Water sprays are installed at several strategic points throughout the crushing plant to keep the dust down to a minimum.

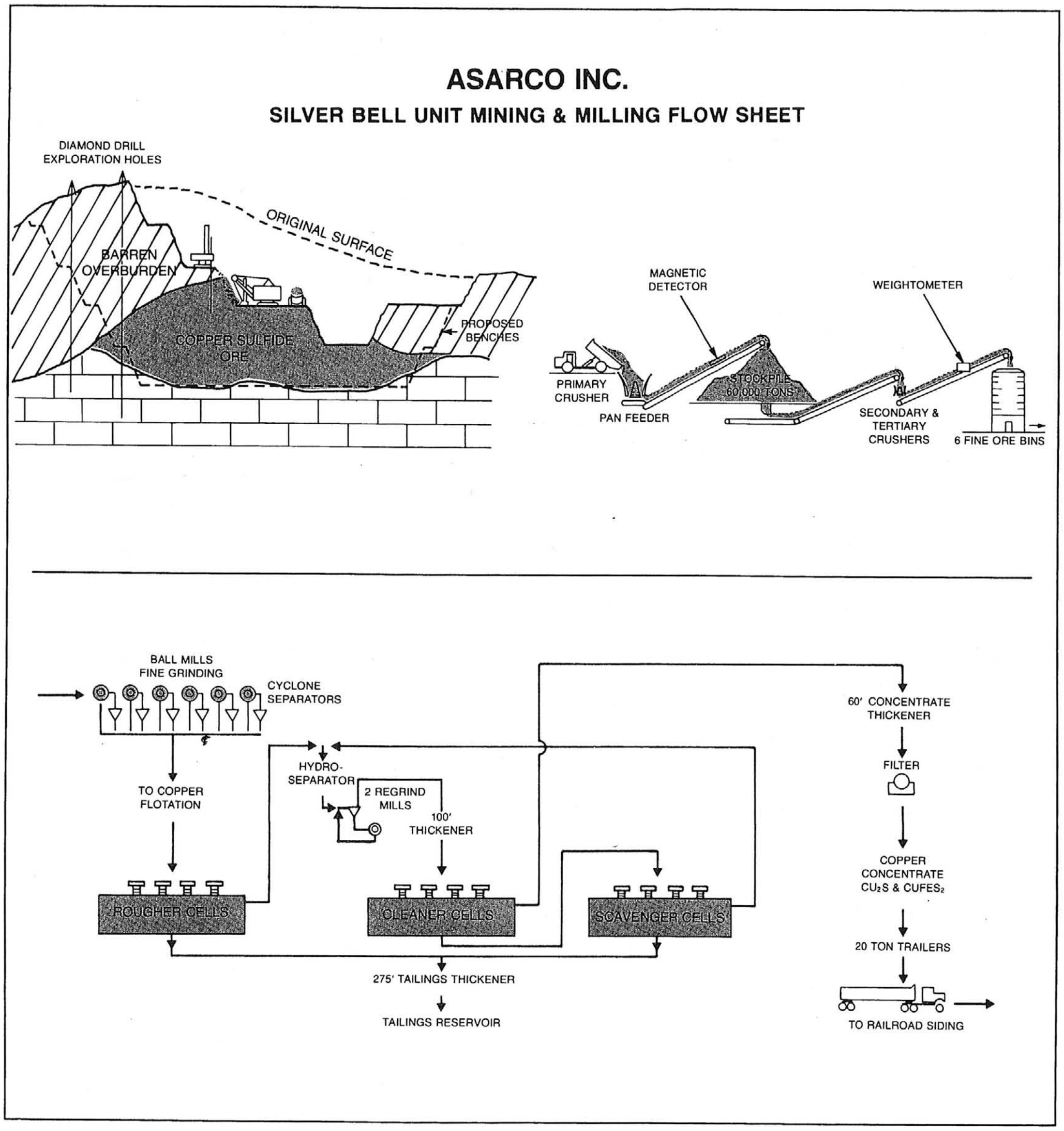
After the ore has been crushed, it is taken to the concentrator building where it is ground and put through flotation cells to separate metal-bearing material from the waste.

Automatic controls (bottom right) are used to keep the size distribution of the flotation feed approximately constant in the face of changing ore hardness. The pulp from the ball mills goes into a 32-cell flotation circuit where reagents are added to the pulp mixture. More than 80 percent of the copper metal values float to the tops of the cells in a froth. The froth is continuously collected and filtered to recover the copper concentrate. Finally, the concentrate is loaded in 20-ton trailer trucks and hauled to Asarco's siding on the Southern Pacific main line near Rillito. The concentrate is transferred into 100-ton bottom-dump rail cars which are then shipped to Asarco smelters in Hayden, Arizona, and El Paso, Texas.



An operator utilizes the Automatic Grinding Control System, employing a computer and varied instrumentation, to give optimum tonnage and to produce a product of desired fineness.

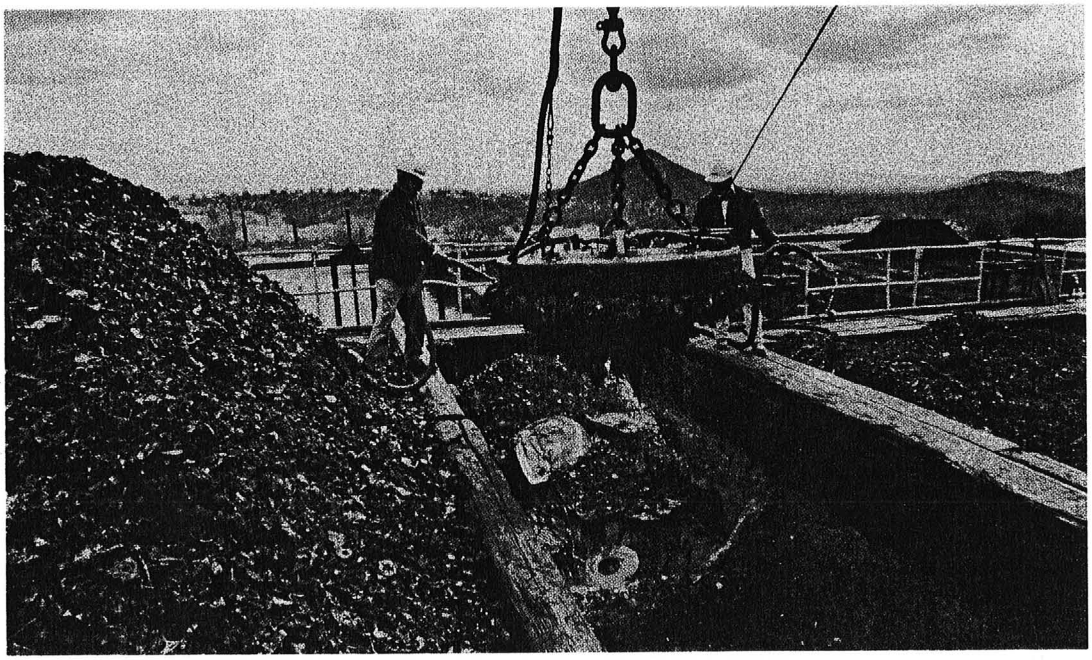
An easy way to look at it all!



Leaching or...
Another way to remove copper

Some of the copper ore in the Silver Bell area cannot be profitably treated by the flotation method in the concentrator. Therefore, another method of recovering the copper called dump leaching is used. Dump leaching began at Silver Bell in January 1960.

Simply described, the process uses sulfuric acid to dissolve copper in the ore. A network of pipelines carries the acid solution to three separate dumps where the copper ore is stored. After dissolving the copper, the solution, now called the pregnant solution, is accumulated in ponds.

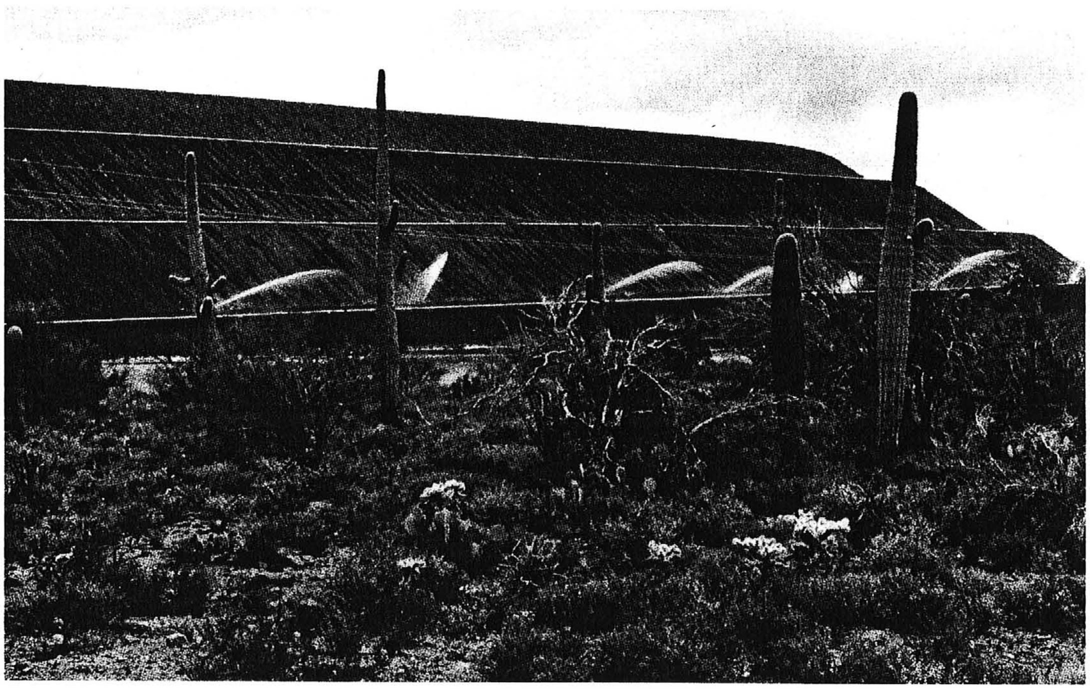


The pregnant solution is then pumped into precipitation cells containing detinned scrap cans (center). The copper in the solution replaces the iron in the cans by galvanic action, creating cement copper.

This copper settles to the bottom of a special holding cell and is washed through a pipe leading to a series of settling tanks. The cement copper is removed and placed on a concrete pad to dry. At the end of the drying process, the copper is placed in a stockpile.

The copper precipitate is then hauled by trucks to the railroad siding. Usually three trailers, each carrying 35,000 to 40,000 pounds of copper precipitate, fill a rail carload. Cement copper averages 82 percent copper and 15 percent moisture.

Helping Arizona remain beautiful!



View of the Revegetated Tailings Dams.

Long before protecting the environment, conserving our natural resources, and fighting pollution became common concerns of the public, Asarco had instituted measures to lessen the impact of mining on the surrounding area.

Dust Control

Dust, even in areas not mined, is a normal Arizona occurrence. At Silver Bell, dust control has always been considered important. Asarco is not only interested in protecting its employees, but in protecting the overall environment as well.

In order to do so, a series of both wet and dry dust collectors are placed in strategic areas, and a water sprinkler system is used in the pits. These precautions greatly reduce the amount of dust in areas surrounding Silver Bell.

Water Conservation

Just as too much dust is a constant concern, too little water is a worry as well! Believing strongly in the conservation and recycling of the Southwest's limited water resources, Asarco has devised a system for reclaiming approximately 70 percent of the water used in production of copper at Silver Bell.

Reclamation and Revegetation Plan

"What grows best in the desert ought to grow best at disturbed mining sites and mineral waste deposits in an arid environment," Asarco's Agronomist for The Southwestern Mining Department theorized in 1973, when he was assigned responsibility for developing a total reclamation-revegetation plan for Asarco mining units in Southern Arizona.

To date, the agronomist's theory seems to be proving out, and the desert's eco-cycle is being restored to normal. At one site, as desert grasses and plants became established, rabbits returned to the mine area and, annoyingly, began to eat the fresh growth. Soon however, the coyotes came back as well! Now there is a relative natural balance among vegetation, rabbits and coyotes.

Summary

Dust control, water conservation, revegetation of disturbed mine sites: these are but a few of the methods used by Asarco personnel to help in the constant battle against pollution and waste. The battle goes on... but both Arizona and Asarco are winning!

Agronomist (above) utilizes a hydromulcher to spray seed material down and across the slopes of the tailings dams.

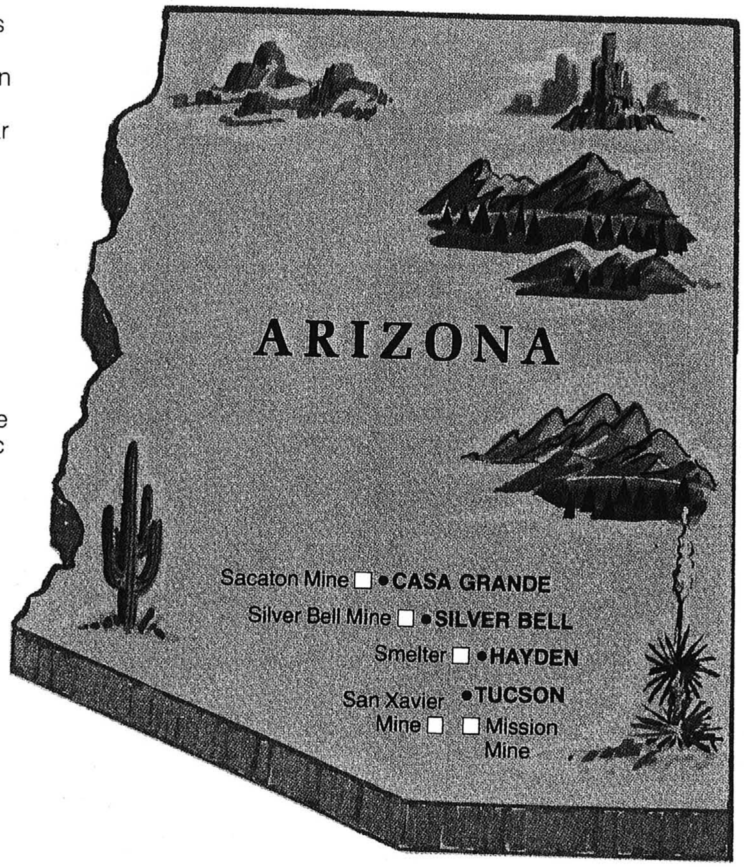
Asarco in Arizona

Asarco has been part of Arizona's growth and prosperity ever since 1911, when construction began on the Hayden copper smelter at Hayden, Arizona. In 1912, the year Arizona became the forty-eighth state, the first copper from the Hayden smelter was poured. Since then, the plant has been enlarged repeatedly.

Asarco's first important Arizona copper mine was developed at Silver Bell, beginning in 1915, as described earlier.

The Mission mine, named after the famed Mission San Xavier del Bac (bottom left) and situated approximately 15 miles southwest of Tucson, was first optioned in December of 1953. Today, it is Asarco's largest wholly owned mining property.

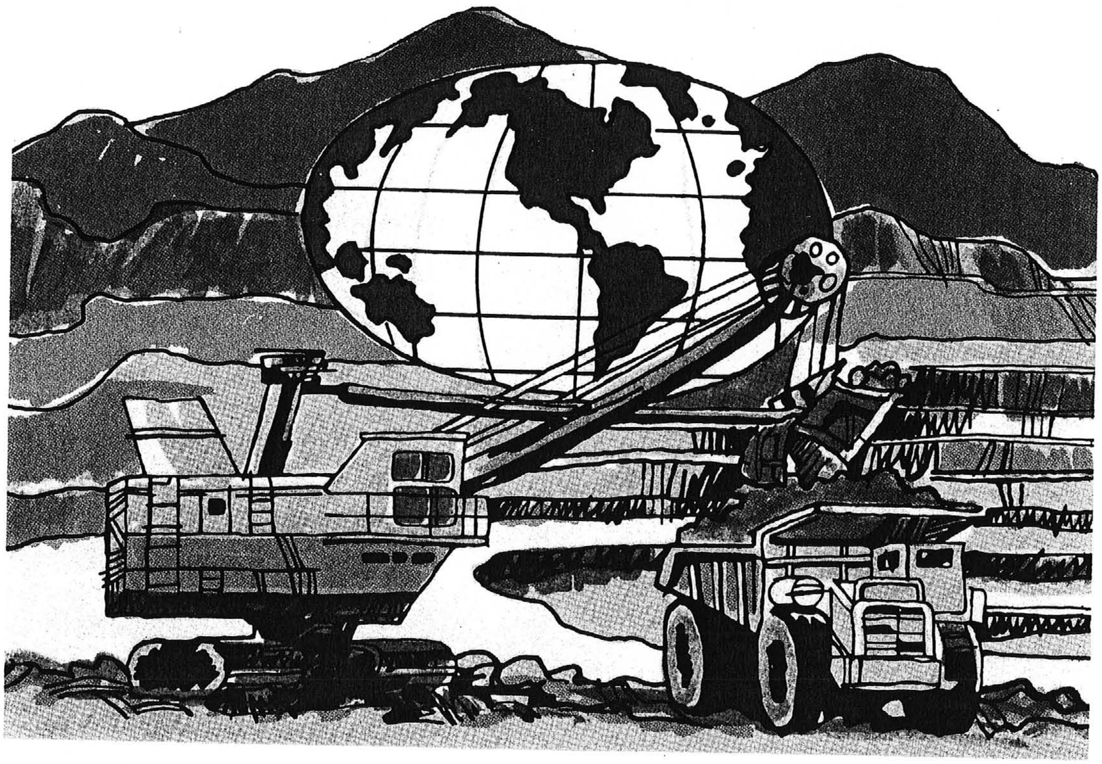
In 1973, production started at Asarco's San Xavier copper mine and leach plant, and in 1974 at the Sacaton mine and mill near Casa Grande.



Asarco's present U.S. copper mines are concentrated in Arizona, "the copper state," which accounts for more than half of the total annual U.S. copper mine output. Today Arizona's mining industry, principally copper, pays a large share of the state's taxes, employs more than five percent of the total workers, and contributes significantly to the state's growth and prosperity.

Arizona has been good for Asarco. Asarco has been good for Arizona.

. . . and the World!



Metal must be mined where it is found. Almost since its inception in 1899, Asarco has been involved in mining ventures, not just in the United States, but outside its boundaries as well. Today, Asarco has a significant interest in three of the world's great mining companies: Industrial Minera Mexico, S.A.; Southern Peru Copper Corporation; and M.I.M. Holdings Limited in Australia. Additionally, it has interests in other mines in Canada, Nicaragua, Peru and Bolivia.

Briefly, Asarco is a company which extracts vital raw materials from the earth and converts them along with those extracted by others into metals and minerals useful to mankind.

HMC

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

Fife Symington, Governor   Edward Z. Fox, Director

MU94-0228

September 15, 1994

To All Concerned Citizens

RE: Permit for: ASARCO Incorporated - SILVER BELL UNIT,
Silver Bell Copper Leaching (SX-EW) Project
Permit No. P-100510

Enclosed are copies of the Responsiveness Summary and Executive Summary, together with a copy of the permit which has been issued.

I appreciate your comments and understand your concerns in this regard. If you have further questions after reading the permit and summaries, please call me at (602) 207-4693.

Sincerely,

Patrick Finton

Patrick Finton
Environmental Engineering Specialist

Enclosures (3)

HMC + Silver Bell file

AQUIFER PROTECTION PERMIT NO. P- 100510

RESPONSIVENESS SUMMARY

August 26, 1994

Facility: ASARCO Incorporated - SILVER BELL UNIT, Silver Bell Copper Leaching (SX-EW) Project

Permittee: ASARCO Incorporated
Silver Bell Unit
25,000 W. Avra Valley Road
Marana, Arizona 85653

Comments (C) and Responses (R):

The Mining Unit did not receive a request for a Public Hearing; therefore, a Public Hearing was not held.

Comment 1

The Department received 58 letters from the general public. All of the letters, except for one, were positive and requested the Department to issue the permit. The one exception letter simply asked for additional information requesting copies from our file..

Response 1

For the one letter requesting information, information was sent, and follow-up phone calls were made to see if the individual needed any additional information.

Comment 2

EPA Region IX requested a time extension to the comment period and asked for additional information.

Response 2

The extension request was denied. The additional information was sent to EPA Region IX.

EXECUTIVE SUMMARY
AQUIFER PROTECTION PERMIT NO. P-100510

Facility Name:

ASARCO, Incorporated - SILVER BELL UNIT, Silver Bell Copper Leaching (SX-EW) Project

Facility Location:

The proposed facility is located in Section 11 of Township 12 S, Range 08 E, Gila and Salt River Baseline and Meridian in Pima County, approximately 17 miles west of Marana, Arizona. The proposed facility is located over the groundwaters of the Tucson A.M.A. Basin and the Pinal A.M.A. Basin.

Facility Description:

The proposed facility is a copper leaching operation consisting of two leach dumps and in-situ leaching of rubblized ore within the existing Oxide And El Tiro open pits, and in the proposed West Oxide and North Silver Bell open pits. Copper ore will be leached with a dilute sulfuric acid solution. Solutions will be collected in lined impoundments and pumped via pipelines to a solvent extraction-electrowinning plant for processing. Solutions stripped of copper will be recycled into the dump and rubble leaching circuits. The facility will process approximately 6,700 gallons of solution per minute and generate approximately 50 tons of copper of 99.99% purity per day.

Best Available Demonstrated Control Technology (BADCT):

The proposed facility BADCT relies on a combination of engineered and site specific hydrogeologic characteristics. Both leach dumps will be constructed in steep-walled canyons resting on fractured bedrock with an average permeability of 1.0×10^{-5} cm/sec. In addition, elements of the Asarco Silver Bell Mine meeting BADCT are as follows:

1. Site prep.
2. Material placement of the #1 and #2 dump leach material so that a very coarse zone of rock lies at the base.
3. Surface runon/runoff control.
4. Solution management.
5. Collection ponds lined with a 60-mil high density polyethylene (HDPE) liner, overlying a prepared subgrade on top of low permeability bedrock.
6. Well defined canyon area for material placement and containment to ensure all solutions and materials stay within the dump.

7. Steep topography within the canyon area that reduces the possibility of solution ponding under the dump.
8. Bedrock outcrops with minimal alluvial cover which minimizes solution head.
9. No nearby surface waters, and the facility is not located within the 100-year flood zone per FEMA maps.\
10. Reconnaissance geologic mapping of the dump leach facilities show no major geologic structures.

All mine shafts and wells that currently exist in the leach dump areas will be backfilled and sealed with an acid-resistant concrete to prevent the shafts and wells from acting as conduits to the subsurface.

The areas designated for rubblized leaching will be fractured using controlled, close-spaced blasting to create zones of fractured rock and high hydraulic conductivity. Controlled blasting will create a surface along which leach solutions will flow and drain to the collection sump in the bottom of the open pits immediately below the rubblized zones. The high contrast in hydraulic conductivity between the rubblized zone and the underlying bedrock will result in minimal losses of leach solution from the leach zones.

All surface impoundments and leach dumps shall be protected from the run-on from the 100-year, 24-hour storm event. All surface impoundments and leach dumps are designed and operated to contain the direct precipitation from the 100-year, 24 storm event plus the normal operating solution volumes and maintain adequate freeboard in the surface impoundments. All excess flows from the leach dumps will be directed to the open pit collections sumps. All flows from the in-situ rubble leach areas will be directed to the open pit collection sumps.

Seven new surface impoundments will be constructed to contain mine leaching solutions (pregnant leach solutions (PLS) and raffinate). The No. 1 and No. 2 PLS collection ponds associated with the No. 1 and No. 2 leach dumps and the distribution raffinate pond shall be constructed with a single 60-mil HDPE liner overlying a prepared and compacted subgrade. These three ponds shall all lie within the zone of capture of the hydrologic sink associated with North Silver Bell open pit. Four surface impoundments (Main Raffinate Pond, Intermediate Raffininate Pond, Intermediate PLS Pond and Plant Feed PLS Pond) shall be lined with primary and secondary 60-mil HDPE with a leak detection system over a prepared and compacted subgrade. All pipelines connecting the facilities in the SX-EW circuit shall be constructed of HDPE or 316 stainless steel pipe.

Monitoring Requirements:

Ambient groundwater quality shall be monitored in ten (10) downgradient and two (2) upgradient monitor wells for a minimum of six (6) quarters prior to the commencement of leaching. The data collected shall be used to calculate alert levels in the point of compliance monitor wells. Monitoring shall be in accordance with PART IV, TABLE II.B., Suite A and Suite B of the permit.

Groundwater quality input monitoring shall be conducted at ten (10) point of compliance wells for hazardous and non-hazardous constituents. Two (2) (MW-1 and MW-10) of the ten (10) monitor wells shall be installed in accordance with the compliance schedule, PART II.H.6, and shall be installed at least two years prior to the initiation of leaching of dump leach No. 2 and West Oxide Rubble, respectively, and in accordance with PART IV, TABLE II.A. and then TABLE II.B.. Two (2) additional monitor wells (MW-8 and MW-12) shall be located and installed pending the completion of the study for the Silver Bell existing facilities in accordance with PART II.C.2.b.. All POC wells are located downgradient of the pollutant management area, which is defined by the boundary of the hydrologic sink formed by the excavation of the open pit below the water table.

Groundwater level monitoring shall be conducted in the monitor wells and in a series of piezometers and drill holes to document the establishment and continued presence of the hydrologic sinks associated with the two existing open pits and the two proposed open pits. The permittee shall conduct a hydrologic survey of the North Silver Bell area and West Oxide area after the first year of excavation of the pits, in accordance with the compliance schedule, PART II.H.9. The permittee shall propose a groundwater level monitoring plan for all new and existing hydrologic sinks for review and approval by the ADEQ APP Section, within one year after the initiation of excavation of the open pits in accordance with PART II.H.7. (Compliance Schedule).

Leaching process solution shall be monitored in accordance with PART IV, TABLE I.A. and TABLE I.B. Discharge limits are established for benzene and PAHs in accordance with PART IV., TABLE I.B.

Compliance with Aquifer Water Quality Standards (AWQS):

All dump leaching and rubble leaching shall be conducted within the zone of capture of the hydrologic sinks (cone of depression) associated with the two proposed and two existing open pits. The permittee has documented the existence of hydrologic sinks associated with the existing Oxide and El Tiro Pits. Hydrologic sinks driven by evaporation or pumping or both are effective in capturing contaminated groundwater and are commonly used to prevent the migration of pollutants to water supply wells. Because all leaching solutions not captured by the leach dump facilities or at the point of collection below the rubble zones will be captured by the hydrologic sinks, it is believed that Aquifer Water Quality Standards will be maintained at the point of compliance.

Point of Compliance:

Twelve points of compliance and monitor wells have been established for this facility in accordance with PART II.C.2 and PART IV, TABLE II.A. and II.B..

Storm/Surface Water Considerations:

The leach dumps, pregnant solution ponds and raffinate ponds shall be protected from the run-on from the 100-year, 24-hour storm event. All surface impoundments and leach pads shall be constructed and operated to contain the direct precipitation resulting from the 100-year, 24-hour storm event plus the normal operating volume of solution without overtopping the impoundments and shall maintain sufficient freeboard in all surface impoundments except during storm events in accordance to PART II.A.6.. Excess flows from the dump leach pads will report to the pit bottom. All flows contacting the rubble leach areas will report to the pit bottoms.

Financial Capability:

The permittee has provided the financial information required by A.A.C. R18-9-108.B.8. Review of that information indicates that the permittee is financially capable to cover the cost of construction, operation, closure and post-closure care.

Technical Capability:

The permittee has and is currently operating hydrometallurgical base metal leaching operation and other mining operations in Arizona and the United States. The permittee's consultant, SHB-AGRA has designed numerous leaching operations in Arizona and the Western United States. Both are believed to be technically capable.

Compliance Schedule:

A compliance schedule has been established in the permit to address permitting of the existing portions of the Silver Bell Unit. The permittee must submit an application for all existing operations within 24 months of the effective date of the permit. The compliance schedule also addresses the establishment of alert levels, construction of monitor wells, development of groundwater level monitoring plans and submittal of a facility emergency response plan.

STATE OF ARIZONA

AQUIFER PROTECTION PERMIT NO. P-100510

PART I. AUTHORIZATION TO DISCHARGE POLLUTANTS IN A MANNER SUCH THAT CURRENT AND REASONABLY FORESEEABLE FUTURE USES OF THE AQUIFER ARE PROTECTED

In compliance with the provisions of Arizona Revised Statutes (A.R.S.) Title 49, Chapter 2, Articles 1, 2 and 3; Arizona Administrative Code (A.A.C.) Title 18, Chapter 9, Article 1; A.A.C. Title 18, Chapter 11, Article 4; and conditions set forth in this permit:

Facility Name: ASARCO Incorporated- SILVER BELL UNIT, Silver Bell Copper Leaching (SX-EW) Project

Owner:
ASARCO Incorporated
180 Maiden Lane
New York, NY 10038

Operator:
ASARCO Incorporated
Silver Bell Unit
25,000 W. Avra Valley Road
Marana, AZ 85653

is authorized to operate the ASARCO Incorporated-SILVER BELL UNIT, Silver Bell Copper Leaching (SX-EW) Project facility located approximately 17 miles west of Marana, Arizona, in Pima County, over groundwater of the Tucson A.M.A. groundwater basin and the Pinal A.M.A. groundwater basin in Township 11 S, Range 08 E, Sections 32, 33, and 34, and in Township 12 S, Range 08 E, Sections 3, 4, 5, 10, 11, and 12, - Gila and Salt River Base Line and Meridian:

Latitude	32° 22' 56.0"	North
Longitude	111° 27' 43.0"	West

This permit shall become effective on the date of the WQD Director's signature and shall be valid for the life of the facility (operational, closure, and post-closure periods) provided that the facility is constructed, operated, and maintained pursuant to all the conditions of this permit according to the design and operational information documented or referenced in PARTS I, II, III, IV, V, VI, and VII of this Permit, and such that Aquifer Water Quality Standards are not violated.

Brian E. Munson
Director
Water Quality Division
Arizona Department of Environmental Quality
Signed this 8 day of September, 1994 4 3SO

PART II. SPECIFIC CONDITIONS

A. Discharge Limitations

1. The permittee is authorized to operate a hydrometallurgical base metal leaching facility. The facility is comprised of two leach dumps; four in-situ (rubble) leach areas, four pregnant leach solution (PLS) ponds, three raffinate ponds, and solution ditches, according to the approved plans and diagrams in the Aquifer Protection Permit (APP) application referenced in PART V.

2. Specific Discharge Limitations are listed in PART IV, TABLE I.A. and I.B.

3. Dump Leach Process

   a. Dump leaching shall be restricted to two (2) leach dumps and associated solution collection and transport ditches, PLS ponds, raffinate ponds, as specified in the approved plans and designs submitted with the APP application referenced in PART V.

   b. A dilute sulfuric acid dump leach process shall be utilized as described in the approved plans submitted with the APP application referenced in PART V.

   c. Leached ore generated by dump leach processing shall not be removed from the dump leach pads. Removal or transfer of leached ore shall be considered a major modification to the facility.

4. In-Situ Rubble Leach Process

   a. The in-situ rubble leach process shall be restricted to four (4) areas and associated solution collection ponds, transport ditches, PLS ponds, and raffinate ponds, as specified in the approved plans and designs submitted with the APP application referenced in PART V.

   b. A dilute sulfuric acid dump leach process shall be utilized as described in the approved plans submitted with the APP application referenced in PART V.

   c. Leached ore generated by in-situ rubble leach processing shall not be removed from the in-situ rubble leach areas. Removal or transfer of leached ore shall be considered a major modification to the facility.

5. Facilities shall be located as follows:

Identifier	Facility	Latitude/Longitude
001A	No. 1 Dump Leach	32°25'50"/111°31'20"
001B	No. 1 PLS Collection Pond	32°26'03"/111°31'47"
002A	No. 2 Dump Leach	32°25'40"/111°32'30"
002B	No. 2 PLS Collection Pond	32°25'51"/111°32'33"
003	North Silver Bell Rubble Leach	32°25'56"/111°32'24"
004	El Tiro Rubble Leach	32°24'57"/111°32'15"
005	West Oxide Rubble Leach	32°23'57"/111°30'52"
006	Oxide Rubble Leach	32°23'50"/111°30'22"
007	Plant Raffinate Pond	32°23'25"/111°29'52"
008	Intermediate Raffinate Pond	32°24'40"/111°31'57"
009	Distribution Raffinate Pond	32°25'28"/111°31'12"
010	Intermediate PLS Pond	32°24'23"/111°32'27"
011	Plant Feed PLS Pond	32°23'18"/111°30'17"

6. All leach dumps, PLS ponds, and raffinate ponds shall be protected from the run-on from the 100-year, 24-hour storm event. All leach dumps, PLS ponds, and raffinate ponds shall be so designed, constructed and operated to contain the direct precipitation from the 100-year, 24-hour storm event plus the normal operating solution volumes and maintain sufficient freeboard to prevent overtopping, with the exception of the No. 1 and No. 2 PLS Collection Ponds. Overflows from the No. 1 and No. 2 PLS Collection Ponds shall flow via spillway to the North Silver Bell open pit collection sumps. Three feet of freeboard shall be maintained in all surface impoundments, with the exception of the No. 1 and No. 2 PLS Collection Ponds, at all times except during storm events and periods of planned maintenance, during which one and one-half (1.5) feet of freeboard shall be maintained.

7. The permittee shall not initiate any dump or in-situ (rubble) leaching prior to the development of the hydrologic sink downgradient of the leaching facilities. No dump or in-situ (rubble) leaching shall occur outside of the capture zone of the hydrologic sinks as defined in the ASARCO letters (see PART V.A.6) and potentiometric map (S-903-06 G) dated August 14, 1992.

B. <u>Summary of BADCT Elements</u>

The elements of the ASARCO Silver Bell Mine meeting BADCT are as follows:

1. Site preparation designed to minimize infiltration, including:

   a. Grubbing the native plants.
   b. Eliminating unconsolidated overburden.
   c. Backfilling and sealing underground mine workings that are under the dumps.
   d. Smoothing the side slopes to eliminate uneven topography.

2. Material placement of the #1 and #2 dump leach material so that a very coarse zone of rock lies at the base.

3. Surface runon\runoff control, consisting of:

   a. A diversion channel designed to divert storm flows associated with a 100 year, 24 hour rain event from entering the facility.

   b. Solution containment structures designed to capture and contain all storm flows that enter the facility associated with a 100 year, 24 hour rain event, in addition to the normal operating volumes.

4. Solution management, consisting of :

   a. Sequencing of leaching activities (wet/dry cycling so that only portions of the leach dumps will be leached at any one time).

   b. Daily inspection of dumps and ponds.

   c. Continual monitoring of the facility, which at a minimum will include the measurement of the solution flows, measuring pond freeboard, pump amps, line pressures, and record keeping of these measurements.

   d. An appropriate contingency plan.

5. Collection ponds which will be lined with a 60-mil high density polyethylene (HDPE) liner, overlying a prepared subgrade on top of low permeability bedrock.

6. Well defined canyon area for material placement and containment to ensure that all solutions and materials stay within the dump.

7. Steep topography within the canyon area that reduces the possibility of solution ponding under the dump.

8. Bedrock outcrops with minimal alluvial cover, which when removed, will minimize the solution head.

9. Low permeability bedrock for the dump leach foundation.

10. No nearby surface waters, and the facility is not located within the 100 year flood zone per FEMA maps.

11. Reconnaissance geologic mapping of the dump leach facilities which shows no major geologic structures that might enhance infiltration.

12. Rubble leaching will take place only within the pit hydrologic sinks and within the ultimate pit limits that the rubblization creates.

C. Monitoring Requirements

All monitoring required in this permit shall continue for the duration of the permit, regardless of the discharge or operational status of the facility, unless otherwise designated in this permit or an approved contingency plan. This monitoring program may be modified, including possible reduction of monitoring frequencies and parameters with Department approval after 24 months from the effective date of this permit. Requests for such changes must be written and include justification for the changes.

1. Discharge Monitoring

Raffinate and PLS from the mine shall be monitored according to PART IV, TABLES I.A. and I.B. in order to characterize potential discharge.

a. Leach Solution Monitoring

(1) The leach solution used in the dump and in-situ (rubble) leach process shall be monitored for inorganic parameters in PART IV, TABLE I.A. on a quarterly basis for four consecutive quarters and then afterward as may be required under the contingency plan should a violation of a permit condition occur.

(2) The leach solution used in the dump and in-situ (rubble) leach process shall be monitored and reported according to the terms and frequencies in PART IV, TABLE I.B.

(3) The permittee may submit a written request to modify Alert Levels for leach solution monitoring. Such a request shall include a summary of adequate test results justifying the change.

2. Groundwater Monitoring

a. Hazardous Point(s) of Compliance

The hazardous substance point(s) of compliance designated for this facility shall be located at the downgradient edge of the pollutant management area in the uppermost aquifer. The following monitor wells shall be constructed and used to monitor for hazardous pollutants:

POC Monitoring Well	Latitude	Longitude
MW-1	32°25'40"N	111°32'54"W
MW-2	32°25'59"N	111°32'51"W
MW-3	32°26'13"N	111°32'32"W
MW-4	32°26'18"N	111°31'48"W
MW-5	32°26'06"N	111°31'00"W
MW-7	32°25'20"N	111°32'42"W
MW-8	To be Determined	
MW-10	To be Determined	
MW-11	32°23'17"N	111°29'47"W
MW-12	To be Determined	

If alert levels for hazardous substances are exceeded at the point(s) of compliance, the permittee may be required to establish additional point(s) of compliance and to monitor at those point(s) of compliance.

b. Non Hazardous Point(s) of Compliance

Monitoring for non hazardous substances shall be conducted at the hazardous substance point(s) of compliance monitor wells. Non hazardous monitor wells will not be installed except pursuant to measures outlined in the contingency plan or this section. The non hazardous substance point(s) of compliance monitor wells shall be located between the facility and the property boundary and the appropriate monitoring points shall be designated and located as follows:

POC Monitoring Well	Latitude	Longitude
NH-1	32°26'37"N	111°31'33"W
NH-2	32°26'58"N	111°33'17"W
NH-3	32°25'54"N	111°33'04"W
NH-4	32°24'57"N	111°33'31"W
NH-5	32°24'22"N	111°33'30"W
NH-6	32°22'33"N	111°32'30"W
NH-7	32°22'33"N	111°30'48"W
NH-8	32°22'37"N	111°29'51"W

If alert levels for non hazardous substances are exceeded at the hazardous substance point(s) of compliance monitor wells, the permittee shall install the appropriate monitor well(s) at the point(s) of compliance established above.

If alert levels for non-hazardous substances are exceeded at the non hazardous point(s) of compliance, the permittee may be required to establish additional point(s) of compliance and to monitor at those point(s) of compliance.

The Director may designate additional points of compliance if information on groundwater gradients or other pertinent information indicates the need.

c. Monitoring Well Locations

A total of 12 monitoring wells shall be constructed at the locations indicated in PART IV, TABLE II.A.

(1) Monitoring wells MW-2, MW-3, MW-4, MW-5, MW-6, MW-7, MW-9, and MW-11 shall be installed a minimum of six quarters prior to operation of Leach Dump No. 1.

(2) Monitoring wells MW-1, and MW-10 shall be installed a minimum of eight quarters prior to the initiation of leaching of leach dump no. 2 and the West Oxide rubble leach, respectively.

The initial location and installation of MW-8, MW-10, and MW-12 will be delayed pending the completion of the study for the Silver Bell existing facilities. Specifically, MW-8 and MW-10 shall be located and installed within 750 feet of the PMA in the area to the south of the El Tiro Pit and proposed West Oxide Pit, and MW-12 shall be located and installed within 750 feet of the PMA to the southeast of oxide pit and to the south of the tailings facilities. (As referenced in PART II.H.10., the permittee shall submit an application for an individual APP for all existing facilities within 24 months of the effective date of this permit.)

All monitoring wells shall be installed and located according to plans approved by the Arizona Department of Water Resources (ADWR) and the ADEQ Aquifer Protection Program Section as referenced in PART V.A. and as stipulated in PART II.C.5.b.

After construction, the ADWR registration numbers of the wells shall be incorporated into this permit in PART IV, TABLE II.A.

d. Ambient Groundwater Quality Monitoring

Within two years, the permittee shall provide 8 quarterly analyses of groundwater samples to establish background ambient water quality data for evaluating any long-term changes in quality in accordance with PART IV, TABLE II.A. The initiation of ambient groundwater monitoring shall occur at least six (6) quarters prior to the initiation of leaching operations.

Within 30 days of receipt of the analyses of the ambient water quality samples, the permittee shall submit a report to the ADEQ Aquifer Protection Program Section with the subsequent quarterly Self-Monitoring Report, required in PART II.I. The report shall include all data and calculations necessary to establish valid ALs and AQLs for each well on a well by well basis. The method for establishing ALs and AQLs shall be as follows:

(1) Aquifer Quality Limits (AQLs)

AQLs shall be established for parameters with primary Aquifer Water Quality Standards (AWQS).

If ambient concentration (mean) plus 3.188 times the standard deviation is below the AWQS, then AQL = AWQS.

If ambient concentration (mean) plus 3.188 times the standard deviations exceeds the AWQS, then AQL = Mean + 3.188 SD.

(2) Alert Levels (ALs)

Alert Levels shall be calculated as follows:

Calculated AL = Mean + 3.188 SD.

and established as follows:

(i) Alert Levels for parameters with primary AWQS

If calculated AL is below primary AWQS, then AL = Calculated AL
If calculated AL exceeds primary AWQS, then no AL shall be established.

(ii) Alert Levels for parameters without primary AWQS

AL = Calculated AL

If "non-detects" are measured for certain parameters during the ambient groundwater monitoring, then upon completion of ambient monitoring, the permittee shall propose an acceptable methodology to calculate, where applicable, the ALs or AQLs for that parameter.

Ambient groundwater monitoring for radiochemicals shall be conducted in accordance with PART IV, TABLE II.A and shall continue for 4 consecutive quarters. At the end of four quarters the permittee shall submit the ambient monitoring data to the ADEQ Aquifer Protection Section for a determination if continued monitoring of radiochemicals is needed. The submittal shall include copies of the laboratory analytical reports and the accompanying QA/QC information. If approved by the ADEQ the monitoring requirement shall be dropped. If not approved by the ADEQ the monitoring frequency shall be reduced to annual.

e. Compliance Monitoring

After completion of the initial ambient groundwater monitoring requirements, the permittee shall continue to monitor each well for the indicator parameters listed in PART IV, Table II.B. Suite B to determine that ALs have not been exceeded. If an AL of an indicator parameter has been exceeded in a well(s), then the permittee shall begin monitoring that well(s) as per PART IV, TABLE II.B. Suite A. on a quarterly basis. Monitoring of Table II.B. Suite A. parameters will continue until the constituent(s) concentration is below the AL or AQL for two consecutive samples.

:tee may submit a written request to reduce the monitoring in PART IV, Table II.B. Suite A. upon completion of the ambient r monitoring program established in accordance with PART d in accordance with the following criteria:

: parameter in question has not been detected for at least six (6) of eight (8) consecutive quarters of the ambient monitoring period, l the detection limit is below any established or proposed numeric uifer Water Quality Standard. If no numeric AWQS exists for the ameter in question, the acceptable detection limit shall be approved advance by the ADEQ Aquifer Protection Section The permittee y propose the use of the practical quantitation limit as an acceptable ection limit if the sample matrix results in difficulties in achieving dard method detection limits;

parameter in question has not been detected in the process itions used in the leaching and solvent extraction-electrowinning cesses, nor is known to be present in the process solutions because ts use as a reagent or because of its presence in a reagent used in process. Acceptable detection limits for the process solutions l be in accordance with PART II.C.2.e.(1).;

zene and the polynuclear aromatic hydrocarbons listed in PART Table I.B. shall not be removed should the contingency for indwater monitoring of these constituents be implemented, unless rwise adequately proven to the Department that benzene and/or PAHs are not present;

analyses shall be performed using the same analytical method for parameter in question such that equivalent detection limits are eved;

permittee shall submit a written report indicating the parameter(s) osed for deletion and accompanied by the supporting data as ined in PART II.C.2.e., including the laboratory analytical rts and quality assurance/quality control data, to the ADEQ ifer Protection Section for review and approval;

n review and approval by the ADEQ the parameters in question be dropped from the list of monitoring parameters.

ial Monitoring

QA/QC Requirements

Pre-operational Monitoring

PROTECTION PERMIT
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ition of the surface impoundment and ers the subgrade shall be inspected ee of sharp objects of any kind that e the liner. Ruts caused by the uipment or by the geomembrane pment must be leveled by hand. The tor or designated quality control m shall inspect the subgrade to insure paration has been achieved and tested e approved criteria submitted with the n, referenced in PART V. and PART plans).

testing shall be conducted on 100% ms. Destructive tests for shear and hall be performed at least every 300 field seam, and at least every 500 ctory seam. Seam testing shall be in th ASTM D4437 (for field seams), 5 (for factory seams), and in h the approved criteria submitted with ication, referenced in PART V and QA/QC) of this permit.

shall install a pump capable of st 10 gpm (14,400 gpd) in the p of the leak detection system to n one (1) foot of head on the r for the following solution ponds: 1) Raffinate Pond, (2) Intermediate l, (3) Intermediate PLS Pond, and (4) S Pond.

, solution ponds, and diversion l be inspected as specified in PART I.

in) Raffinate Pond (007), Intermediate 1 (008), Intermediate PLS Pond (010), Feed PLS Pond (011) leak detection e monitored for fluid presence on a nd pumped as needed. Records of the d shall be maintained by the permittee for a period of five (5) years from the ion.

b. Facility Maintenance Inspection

(1) The facility and pollution control structures shall be inspected for the items listed in PART IV, TABLE III. A log of these inspections shall be kept at the facility for five (5) years from the date of each inspection, available for review by ADEQ personnel.

(2) If any damage of the pollution control structures is identified during inspection, proper repair procedures shall be performed. All repair procedures and material(s) used shall be documented on the Self-Monitoring Report and Documentation Form and submitted quarterly to the ADEQ, Aquifer Protection Program Section. If no damage to the pollution control structures is identified during the quarter, the permittee shall indicate that the required inspections occurred during the quarter.

4. Sampling Protocols

a. Discharge Monitoring

(1) Leach Process Solution Monitoring

The permittee shall conduct leach process solution monitoring in accordance with PART IV, TABLE I.A. and TABLE I.B.

Daily process solution monitoring shall be performed in accordance with the permittee's standard procedures for process control solution analyses.

b. Groundwater Monitoring

(1) Sampling procedures, preservation techniques and holding times shall be consistent with the May, 1991 ADEQ Quality Assurance Project Plan.

(2) Static water levels shall be measured and recorded prior to sampling. Wells shall be purged of at least three borehole volumes (as calculated using the static water level) or until indicator parameters (pH, temperature, conductivity) are stable, whichever represents the greater volume. If evacuation results in the well going dry, the well should be allowed to recover to 80% of the original borehole volume. An explanation for reduced pumping volumes, a record of the volume pumped, and modified sampling procedures shall be reported on the Self-Monitoring Report and Documentation Form.

c. Operational Monitoring

(1) Freeboard Monitoring

All freeboard measurements shall consist of the vertical distance between the fluid surface and the lowest point on the berm of the pond.

5. Installation and Maintenance of Monitoring Equipment

a. Monitoring Equipment

The permittee shall provide monitoring or sampling access, ports or devices at the facility for all monitoring required by this permit.

b. Groundwater Monitoring Equipment

All groundwater monitoring wells, required by this permit, shall be installed and maintained according to plans approved by the ADEQ Aquifer Protection Program Section so that proper groundwater samples can be collected. Should additional groundwater wells be determined necessary, the construction details shall be submitted to the ADEQ Aquifer Protection Program Section for approval.

6. Monitoring Records

a. Discharge Monitoring Records

(1) The following information associated with each sample, inspection or measurement and the name of each individual who performed the sampling or measurement should be included in the monitoring records;

(a) Date, time and exact place of sampling, inspection, or measurement and the name of each individual who performed the sampling or measurement.

(b) Procedures used to collect the sample or make the measurement.

(c) Date on which sample analysis was completed.

(d) Name of each individual and laboratory who performed the analysis.

(e) Analytical techniques or methods used to perform the sampling and analysis.

(f) Chain of custody records.

(g) Any field notes relating to the information described in subparagraphs a through f above.

(2) Operational Monitoring/Facility Inspection Records

(a) Facility Inspection Records

The following information shall be recorded for weekly facility inspections:

Name of inspector, date and approximate time of inspection, condition of facility components listed in PART IV, TABLE III, and any damage or malfunction and repairs performed.

(3) Process Solution Monitoring

The permittee shall record the date on which daily measurements of solution flowrates and solution levels of each pond are taken. Chain of custody forms are not required for daily process solution monitoring.

(4) Groundwater Monitoring Records

All information required in PART II.C.6.a.(1) shall be recorded for each groundwater sample collected as required by this permit.

D. Contingency Plan Requirements

The permittee shall maintain at least one copy of the approved contingency plan(s) at the location where day-to-day decisions regarding the operation of the facility are made. The permittee shall revise promptly all copies of the contingency plan(s) to reflect approved changes. The permittee shall advise anyone responsible for the operation of the facility of the location of copies of all contingency and emergency plans. In addition to any information contained in the contingency plan referenced in Part V.A, at a minimum, the following contingency requirements shall be implemented.

1. AL/DL/AQL Contingencies

a. Discharge Alert Level Exceedance

(1) Primary Leachate Collection Sumps in Surface Impoundments (PLS and Raffinate Ponds)

The permittee shall initiate the following actions within five days of becoming aware that the volume pumped from a leak detection sump is greater than 5,000 gpd.

(a) Conduct the necessary tests to determine the location of leaks in the primary liner, including, if necessary, emptying of the impoundment.

(b) Quantify and record the amount of fluid pumped from the leachate collection system.

(c) Repair all identified points of leakage into the leachate collection system.

(2) Benzene and Polynuclear Aromatic Hydrocarbon (PAH) Monitoring

Within 30 days of becoming aware of an exceedance of the alert level or discharge limit for benzene and/or the five PAHs listed in PART IV, TABLE I.B., the permittee shall initiate monitoring for benzene and PAHs in the facility point of compliance monitor wells for eight quarters and thereafter monitor on an annual sampling and reporting frequency. The results of the initial groundwater sampling shall be submitted to the ADEQ Aquifer Protection Program Section within 30 days of receipt of the results. The Department may require additional monitoring, studies or remedial activities beyond those specified in the permit.

2. General AL/AQL/DL Contingencies

Alert Level (AL), Discharge Limit (DL) or Aquifer Quality Limit (AQL) Exceedance

a. The permittee shall notify the Department at the address specified in PART II.I.1 within five days of becoming aware of the exceedance of an Alert Level, Discharge Limit or Aquifer Quality Limit.

b. Verification sampling shall be conducted within 15 (fifteen) days of becoming aware that Alert Level, Discharge Limit or Aquifer Quality Limit has been exceeded.

c. Within five days of receiving the results of verification sampling from the laboratory, the permittee shall notify the Department of the results, at the address indicated in PART II.I.1, regardless of whether the results are positive or negative.

(1) If the results of verification sampling indicate that an AL, DL or AQL has not been exceeded, the permittee shall assume that no exceedance has occurred; no further action is required until the next scheduled monitoring round.

(2) If the results verify that a DL or AQL has been exceeded, the permittee shall, within 30 days of receiving the laboratory results verifying that a DL, or AQL has been exceeded, submit to the ADEQ, Aquifer Protection Program Section, either (a) or (b) of the following:

(a) a written report which includes the documentation specified in PART II.I.3.b. Upon approval by the Department, the permittee shall initiate the actions necessary to mitigate the impacts of the violation. At a minimum, the plan shall include provisions for more frequent sampling until constituent concentration is below the AL, DL or AQL for two consecutive samples. The plan shall indicate if any additional parameters are to be tested.

(b) a demonstration that the DL or AQL exceedance resulted from error(s) in sampling, analysis, or statistical evaluation.

(3) If the results verify that an AL has been exceeded, the permittee shall, if requested by the Director, within 30 days of receiving the laboratory results verifying that an AL has been exceeded, submit to the ADEQ Aquifer Protection Program Section, either (a) or (b) of the following:

(a) a written report describing the causes, impacts or mitigation of the discharge.

(b) a demonstration that the AL exceedance resulted from error(s) in sampling, analysis, or statistical evaluation.

(4) Upon review of the report documenting an AL, DL, or AQL exceedance, the Department may require additional monitoring and/or action beyond those specified in this permit.

3. Accidental Discharge

a. The permittee shall correct any failure that results in an accidental discharge and take the following actions:

(1) Within 30 days of an accidental discharge that might cause the exceedance of an AQL or might cause imminent and substantial endangerment to public health or the environment, the permittee shall submit to the ADEQ Aquifer Protection Program Section a written report that includes the documentation required in PART II.I.3.

(2) Upon review of the above required report, the Department may require additional monitoring and/or actions.

b. Emergency Response

(1) The permittee shall provide for emergency response on a 24-hour basis in the event that a condition arises which results in imminent and substantial endangerment to public health or the environment. The plan shall be kept at the facility and provide for the following:

(a) designation of an emergency response coordinator who shall notify ADEQ, Aquifer Protection Program Section and activate the necessary contingency plan in the event of an emergency;

(b) a general description of the procedures, personnel and equipment to be used to assure appropriate mitigation of unauthorized discharges; and

(c) a list of names, addresses and telephone numbers of persons to be contacted in the event of an emergency.

(2) The emergency response coordinator shall notify the ADEQ, Aquifer Protection Program Section immediately in the event that emergency response measures are taken or those portions of the contingency plan that address an imminent and substantial endangerment are activated.

4. Slope Failures

If a slope failure involving the leach dumps, rubblized zones, surface impoundments or liners occurs the permittee shall promptly close the active area in the vicinity of the failure, and conduct a field investigation of the failure to analyze its origin and extent, its impact on the facility operations, temporary and permanent repairs and changes in operational plans considered necessary.

E. Temporary Cessation

The permittee shall notify the ADEQ Aquifer Protection Program Section in writing before any temporary cessation of operations at the facility. Notification of the temporary cessation does not relieve the permittee of any permit requirements unless otherwise specified in this permit.

Accompanying the notification shall be a description of any measures to be taken to maintain discharge control systems such that discharge is minimized to the maximum extent practicable during temporary cessation.

F. Closure

1. The permittee shall notify the ADEQ, Aquifer Protection Program Section of the intent to cease, without intent to resume, an activity for which the facility was designed or operated prior to ceasing. Within 90 days following notification, the permittee shall submit for approval, to ADEQ Aquifer Protection Program Section, a closure plan which eliminates, to the greatest extent practicable, any reasonable probability of further discharge from the facility and of exceeding Aquifer Water Quality Standards at the applicable point of compliance. This plan shall be in addition to the approved closure method referenced in the facility file. The plan shall describe the following details:

   a. The approximate quantities and the chemical, biological, and physical characteristics of the materials to be removed from the facility;

   b. the destination of the materials to be removed from the facility and an indication that placement of the materials at that destination is approved;

   c. the approximate quantities and the chemical, biological, and physical characteristics of the materials that will remain at the facility;

   d. the methods to be used to treat any materials remaining at the facility;

   e. the methods to be used to control the discharge of pollutants from the facility;

   f. any limitations on future land or water uses created as a result of the facility's operations or closure activities;

   g. the methods to be used to secure the facility;

   h. an estimate of the cost of closure; and

   i. a schedule for implementation of the closure plan and the submission of a post-closure plan.

2. Upon completion of closure activities, the permittee shall give written notice to ADEQ Aquifer Protection Program Section indicating that the approved closure plan has been fully implemented.

G. Post-Closure

1. Post-closure requirements by the ADEQ, Water Permit Unit will be based on the review of facility closure activities.

2. The post-closure plan shall ensure that any reasonable probability of further discharge from the facility, and of exceeding Aquifer Water Quality Standards at the applicable points of compliance, are eliminated, to the greatest extent practicable. If a modified post-closure plan is deemed to be necessary, the modified plan shall describe all of the following:

a. The duration of the post-closure care.

b. The monitoring procedures to be implemented by the permittee, including monitoring frequency, type, and location.

c. A description of the operating and maintenance procedures to be implemented for aquifer quality protection devices, such as liners, treatment systems, pump-back systems, and monitoring wells.

d. A schedule and description of physical inspections to be conducted at the facility following closure.

e. An estimate of the cost of post-closure maintenance and monitoring.

f. A description of limitations on future land or water uses, or both, at the facility site as a result of facility operations.

3. The permittee shall notify ADEQ Aquifer Protection Program Section in writing when the post-closure activities have been completed.

4. At a minimum, post-closure requirements shall include maintenance and monitoring activities, as described in the plans referenced in PART IV, TABLE III and PART V.A. These shall essentially consist of: periodic verification that all the containment and monitoring structures and facilities retain their integrity and their operability; appropriate repairs as necessary; and monitoring of groundwater and leachate. These activities will continue for a period of time to be determined at the time of closure, and approved by the ADEQ Aquifer Protection Program Section, and neither shall their frequency be modified nor the monitoring ceased without approval by the ADEQ.

H. Compliance Schedule Requirements

1. The permittee shall submit to the ADEQ Aquifer Protection Program Section within 24 months of the effective date of the permit, the tabulated ambient groundwater monitoring data as required in PART IV TABLE II.

2. The permittee shall, within 24 months of the effective date of the permit, or prior to the initiation of leaching, whichever comes first, submit to the ADEQ Aquifer Protection Program Section, a report which includes the statistical calculations of the alert levels and aquifer quality limits to be established for the point of compliance monitor wells. The report shall include copies of the laboratory analytical reports and the QA/QC procedures using in collection and analysis of the samples.

3. The permittee shall, within 60 days of the effective date of the permit, submit a copy of a facility emergency response plan to the ADEQ Aquifer Protection Program Section. The plan shall include the information as referenced in PART II.D.3.b.

4. The permittee shall submit to the ADEQ Aquifer Protection Program Section, within 30 days of the completion of construction, the as-built construction drawings for all leach dumps, liner systems, PLS ponds, raffinate ponds, and storm water diversion structures. All construction drawings shall be signed and sealed by a professional engineer registered in the State of Arizona.

5. The permittee shall, within 30 days of completion of construction of the facilities referenced in PART II.H.4., submit the results of all quality assurance/quality control testing to the ADEQ Aquifer Protection Program Section.

6. The permittee shall install groundwater monitor wells MW-1 and MW-10 at least 24 months prior to the initiation of leaching activities at leach dump No. 2 and the West Oxide Pit rubble leach, respectively. MW-1 and MW-10 shall be monitored in accordance with PART IV, TABLE II.A., and the ambient monitoring data and statistical AL and AQL calculation shall be submitted to the ADEQ Aquifer Protection Program Section prior to the initiation of leaching operations at leach dump No. 2 and the West Oxide Pit rubble leach for review, approval and incorporation into the permit and in accordance with PART II.C.2.d. Upon the completion of ambient monitoring the permittee shall conduct monitoring of MW-1 and MW-10 in accordance with PART IV, TABLE II.B. Suite B.

7. The permittee shall submit to the ADEQ Aquifer Protection Program Section a report documenting the existing hydrologic conditions in the North Silver Bell open pit and surrounding areas and the West Oxide open pit and surrounding areas prior to the initiation of leaching operations, but no longer than one year after the initiation of excavation of the open pits.

8. The permittee shall, within 30 days of the initiation of pre-mine activities, submit notification to the ADEQ Aquifer Protection Program Section of the initiation of pre-mine activities. Pre-mine activity is conventional truck and shovel mining that is performed prior to actual leaching.

9. The permittee shall, at the end of the one year pre-mine activities, submit to the ADEQ Aquifer Protection Program Section a proposal for a groundwater level monitoring plan, including proposed locations of fixed piezometer pairs and other measurement locations, proposed frequency of monitoring and reporting, and proposed minimum sample point density for the Oxide, West Oxide, El Tiro and North Silver Bell open pits and surrounding areas. Upon review and approval by the ADEQ Aquifer Protection Program Section the monitoring plan shall be incorporated into the permit.

10. The permittee shall, within 24 months of the effective date of the permit, submit an application for an individual Aquifer Protection Permit for all existing facilities and existing discharging activities at the ASARCO Silver Bell Unit, including, but not limited to all leaching operations, surface impoundments, tailings facilities and pollution control facilities.

11. The permittee shall submit, within thirty days of receipt of the fourth quarter results of polynuclear aromatic hydrocarbon (PAH) monitoring, a written report to the ADEQ Aquifer Protection Program Section proposing the alert levels for the five PAHs. The alert levels shall be based on the practical quantitation limits achieved during analysis of the four quarterly samples during the first year of monitoring, if the practical quantitation limits exceed 0.005 milligrams per liter (mg/L). The permittee shall direct the analytical laboratory to take the steps necessary to achieve the lowest detection limits possible. Upon review and approval by the ADEQ Aquifer Protection Program Section the alert levels shall be incorporated into the permit.

If at any time during the life of the permit, the permittee is able to adequately prove to the Department that neither Benzene nor one of the five PAHs are present in the process solution, then upon review and approval by the Department, Benzene and/or one the PAHs shall be dropped from the list of monitoring parameters.

I. <u>Reporting Requirements</u>

1. Reporting Location

Signed copies of all reports required herein shall be submitted to the Department at:

Arizona Department of Environmental Quality
Aquifer Protection Program Section
3033 North Central Ave
Phoenix, Arizona 85012
Phone Number: (602) 207-4622

2. Monitoring Reporting

a. The permittee shall complete the Self-Monitoring Report and Documentation Form provided by the Department to reflect facility inspection requirements designated in PART IV, TABLE III and submit to the ADEQ, Aquifer Protection Program Section quarterly along with other reports required by this permit. Facility inspection reports shall be submitted no less frequently than quarterly, regardless of operational status.

b. PART IV, TABLES I.A., I.B., II.A., and II.B. contain the frequency for reporting results from discharge and groundwater monitoring requirements. Results shall be submitted in the Self-Monitoring Report Form. Monitoring methods shall be recorded and any deviations from the methods and frequencies prescribed in this permit shall be reported.

c. The permittee shall complete the Self-Monitoring Report Forms, to be supplied by the Department, to the extent that the information reported may be entered on the form. The results of all monitoring required by this permit shall be submitted in such a format as to allow direct comparison with the limitations and requirements of the permit.

3. Permit Violation Reporting

a. The permittee shall notify the ADEQ Aquifer Protection Program Section within five days of becoming aware of a violation of any permit condition.

b. The permittee shall submit a written report within 30 days after becoming aware of the violation of a permit condition. The report shall document all of the following:

(1) A description of the violation and its cause;

(2) the period of violation, including exact date(s) and time(s), if known, and the anticipated time period during which the violation is expected to continue;

(3) any action taken or planned to mitigate the effects or the violation, or to eliminate or prevent recurrence of the violation;

(4) any monitoring activity or other information which indicates that any pollutants would be reasonably expected to cause a violation of an Aquifer Water Quality Standard; and

(5) any malfunction or failure of pollution control devices or other equipment or process.

4. Modification Reporting

a. All requests for permit modifications shall be done in accordance with PART VI.H.3., unless otherwise specified in this permit.

b. Requests for a major modification to a facility (as defined in PART V.C.24.) shall be submitted at least 180 calendar days before making the major modification.

5. Operational Reporting

a. The permittee shall report operational conditions listed in PART IV, TABLE III in the Self-Monitoring Report form quarterly. If none of the conditions occur, the report shall say "no event"for a particular reporting period. If the facility is not in operation, the permittee shall indicate that fact in the Self-Monitoring Report.

b. The permittee shall submit data required in PART IV, TABLES I through IV regardless of the operating status of the facility unless otherwise approved by the Department or allowed in this permit.

6. Self-Monitoring Reports

The Self-Monitoring Report shall include: Copies of laboratory analysis forms, documentation on sampling date and time, name of sampler, static water level prior to sampling, sampling method, purging volume, indicator parameters, analytical method, method detection limit, date of analysis, preservation and transportation procedures, and analytical facility. Data shall be compiled on standardized forms which allow comparison with past reports.

7. Samples taken report due by:

Samples taken during quarter beginning	Quarterly Report due by
Jan	Apr 28
Apr	Jul 28
Jul	Oct 28
Oct	Jan 28

PART III. OTHER CONDITIONS

A. Analytical Methodology

The water samples shall be analyzed using EPA approved methods or Arizona State approved methods listed in PART IV, TABLES I and II. Alternative EPA or Standard Methods may be substituted for the methods specified in PART IV so long as equivalent or better detection limits are achieved. The analysis shall be performed by a laboratory licensed by the Arizona State Laboratory. For results to be considered valid, all analyses shall be performed by a licensed and certified laboratory and all analytical work shall meet quality control standards specified in the approved methods. A list of certified laboratories can be obtained at the address listed below:

Arizona Department of Health Services
Office of Laboratory Licensure and Certification
3443 North Central Avenue
Phoenix, Arizona 85012
Phone Number: (602) 255-3454

B. Environmental Laboratory Contact

Upon submittal of the samples to a state-certified laboratory for analysis, a copy of the appropriate portions of the signed permit shall be forwarded to the laboratory for reference.

PART IV. TABLES

DISCHARGE MONITORING

TABLE I.A
LEACHING PROCESS SOLUTION MONITORING

Sampling Point Number	Identification	Location
001B	No. 1 PLS Collection Pond	32°26'03" N/111°31'47" W
007	Plant (Main) Raffinate Pond	32°23'25" N/111°29'52" W

Parameter	Discharge Limit [1]	Alert Level [2]	Analytic Method [3]	Monitoring Frequency	Reporting Frequency
Suite A General Inorganics					
				Quarterly for four quarters; As may be required by contingency plan thereafter	Quarterly for four quarters; As may be required by contingency plan thereafter
pH (field)	N/A	N/A	N/A	"	"
Specific Conductance (field)	N/A	N/A	N/A	"	"
Temperature (field)	N/A	N/A	N/A	"	"
pH (lab)	N/A	N/A	EPA 150.1	"	"
Specific Conductance (lab)	N/A	N/A	EPA 120.1	"	"
Temperature (lab)	N/A	N/A	EPA 170.1	"	"
Calcium	N/A	N/A	EPA 215	"	"
Magnesium	N/A	N/A	EPA 242.1	"	"
Potassium	N/A	N/A	EPA 258.1	"	"
Sodium	N/A	N/A	EPA 273.1	"	"
Chloride	N/A	N/A	EPA 325	"	"
Fluoride	N/A	N/A	EPA 340	"	"
Nitrate-Nitrite as N	N/A	N/A	EPA 353	"	"
Sulfate	N/A	N/A	EPA 375	"	"
Hardness [4]	N/A	N/A	Calculation	"	"
Total Dissolved Solids (TDS)	N/A	N/A	EPA 160.1	"	"

TABLE I.A (Cont.)

Metals [5]:

Antimony	N/A	N/A	EPA 204	"	"
Arsenic	N/A	N/A	EPA 206	"	"
Barium	N/A	N/A	EPA 208	"	"
Beryllium	N/A	N/A	EPA 210	"	"
Cadmium	N/A	N/A	EPA 213	"	"
Chromium	N/A	N/A	EPA 218	"	"
Copper	N/A	N/A	EPA 220	"	"
Iron	N/A	N/A	EPA 236	"	"
Lead	N/A	N/A	EPA 239	"	"
Manganese	N/A	N/A	EPA 243	"	"
Mercury	N/A	N/A	EPA 245	"	"
Nickel	N/A	N/A	EPA 249	"	"
Selenium	N/A	N/A	EPA 270	"	"
Thallium	N/A	N/A	EPA 279	"	"
Zinc	N/A	N/A	EPA 289	"	"

Radiochemicals[5]:

Gross Alpha Particle Activity	N/A	N/A	EPA 900.1	Quarterly for four quarters; As per contingency plan thereafter	Quarterly for four quarters; As per contingency plan thereafter
Radium- 226	N/A	N/A	EPA 903.1	"	"
Radium- 228	N/A	N/A	EPA 904	"	"
Uranium (total) [6]	N/A	N/A	EPA 908	"	"
Radon- 222 [6]	N/A	N/A	EPA 908	"	"

TABLE I.B
GENERAL ORGANICS

Sampling Point Number	Identification	Location
001B	No. 1 PLS Collection Pond	32°26'03" N/111°31'47" W
007	Plant (Main) Raffinate Pond	32°23'25" N/111°29'52" W

Parameter	Discharge Limit [1]	Alert Level [2]	Analytic Method [3]	Monitoring Frequency	Reporting Frequency
Flow Rate (Pond 011)	9000 gpm	N/A	Flow Meter	Daily	Quarterly
Benzene	Reserved	0.005	EPA 602	Quarterly for four quarters; thereafter annually	Quarterly for four quarters; thereafter annually
Benzo (b) fluoranthene	Reserved	*	EPA 610	"	"
Benzo (a) pyrene	Reserved	*	EPA 610	"	"
Dibenzo (a,h) anthracene	Reserved	*	EPA 610	"	"
Dibenzo (a,i) pyrene	Reserved	*	EPA 610	"	"
Indeno (1,2,3- cd) pyrene	Reserved	*	EPA 610	"	"

TABLE II.A
AMBIENT GROUNDWATER MONITORING

Sampling Point Number	Well Number	Cadastral Location (x-y-z)NN	ADWR Registration Number	Latitude	Longitude
01	MW- 1			32 25' 40" N	111 32' 54" W
02	MW- 2			32 25' 59" N	111 32' 51" W
03	MW- 3			32 26' 13" N	111 32' 32" W
04	MW- 4			32 26' 18" N	111 31' 48" W
05	MW- 5			32 26' 06" N	111 31' 00" W
06	MW- 6			32 25' 15" N	111 31' 08" W
07	MW- 7			32 25' 20" N	111 32' 42" W
08	MW- 8			To be Determined	
09	MW- 9			32 24' 09" N	111 30' 13" W
10	MW- 10			To be Determined	
11	MW- 11			32 23' 17" N	111 29' 47" W
12	MW- 12			To be Determined	

TABLE II.A. (Cont.)

Parameter	Analytical Method [3]	Sampling Frequency	Reporting Frequency
General Inorganics:			
pH (field)	N/A	Qtly for 8 Qtrs	Qtly for 8 Qtrs
Specific Conductance (field)	N/A	"	"
Temperature (field)	N/A	"	"
pH (lab)	EPA 150.1	"	"
Specific Conductance (lab)	EPA 120.1	"	"
Temperature (lab)	EPA 170.1	"	"
Calcium	EPA 215	"	"
Magnesium	EPA 242.1	"	"
Potassium	EPA 258.1	"	"
Sodium	EPA 273.1	"	"
Alkalinity (Total)	EPA 310	"	"
Bicarbonate [7]	Calculation	"	"
Chloride	EPA 325	"	"
Fluoride	EPA 340	"	"
Nitrate- Nitrite as N	EPA 353	"	"
Sulfate	EPA 375	"	"
Hardness	Calculation	"	"
Total Dissolved Solids (TDS)	EPA 160.1	"	"
Metals [5]:			
Antimony	EPA 204	Qtly For 8 Qtrs	Qtly For 8 Qtrs
Arsenic	EPA 206	"	"
Barium	EPA 208	"	"
Beryllium	EPA 210	"	"
Cadmium	EPA 213	"	"
Chromium	EPA 218	"	"
Copper	EPA 220	"	"
Iron	EPA 236	"	"
Lead	EPA 239	"	"
Manganese	EPA 243	"	"
Mercury	EPA 245	"	"
Nickel	EPA 249	"	"
Selenium	EPA 270	"	"
Thallium	EPA 279	"	"
Zinc	EPA 289	"	"

TABLE II.A. (Cont.)

Radiochemicals [5,6]:

Gross Alpha Particle Activity	EPA 900.1	Quarterly for 4 quarters	Quarterly for 4 quarters
Radium 226	EPA 903.1	"	"
Radium 228	EPA 904	"	"
Uranium (total) [6]	EPA 908	"	"
Radon 222 [6]	EPA 908	"	"

TABLE II.B
GROUNDWATER MONITORING

Sampling Point Number	Well Number	Cadastral Location (x-y-z)NN	ADWR Registration Number	Latitude	Longitude
01	MW- 1			32 25' 40" N	111 32' 54" W
02	MW- 2			32 25' 59" N	111 32' 51" W"
03	MW- 3			32 26' 13" N	111 32' 32" W
04	MW- 4			32 26' 18" N	111 31' 48" W
05	MW- 5			32 26' 06" N	111 31' 00" W
07	MW- 7			32 25' 20" N	111 32' 42" W
08	MW- 8			To be Determined	
10	MW- 10			To be Determined	
11	MW- 11			32 23' 17" N	111 29' 47" W
12	MW- 12			To be Determined	

TABLE II.B., SUITE A

Parameter	AQL (mg/l) [1]	Alert Level [2]	Analytical Method [3]	Sampling Frequency	Reporting Frequency
Suite A-General Inorganics:					
				As Per Contingency Plan	As Per Contingency Plan
Calcium	N/A	Reserved	EPA 215	"	"
Magnesium	N/A	Reserved	EPA 242.1	"	"
Potassium	N/A	Reserved	EPA 258.1	"	"
Sodium	N/A	Reserved	EPA 273.1	"	"
Alkalinity (Total)	N/A	Reserved	EPA 310	"	"
Bicarbonate [7]	N/A	Reserved	Calculation	"	"
Chloride	N/A	Reserved	EPA 325	"	"
Fluoride	Calculated	Reserved	EPA 340	"	"
Hardness [4]	N/A	Reserved	Calculation	"	"
Nitrate - Nitrite as N	Calculated	Reserved	EPA 353	"	"
Suite A-Metals [5]:					
Antimony	Calculated	Reserved	EPA 204	As Per Contingency Plan	As Per Contingency Plan
Arsenic	Calculated	Reserved	EPA 206	"	"
Barium	Calculated	Reserved	EPA 208	"	"
Beryllium	Calcualted	Reserved	EPA 210	"	"
Cadmium	Calculated	Reserved	EPA 213	"	"
Chromium	Calculated	Reserved	EPA 218	"	"
Lead	Calculated	Reserved	EPA 239	"	"
Mercury	Calculated	Reserved	EPA 245	"	"
Nickel	Calculated	Reserved	EPA 249	"	"
Selenium	Calculated	Reserved	EPA 270	"	"
Thallium	Calculated	Reserved	EPA 279	"	"
Suite A- Radiochemicals [5]:					
Gross Alpha Particle Activity	Calculated	Reserved	EPA 900.1	As Per Contingency Plan	As Per Contingency Plan
Radium-226	Calculated	Reserved	EPA 903.1	"	"
Radium-228	Calculated	Reserved	EPA 904	"	"
Uranium (total) [6]	N/A	Reserved	EPA 908	"	"
Radon-222 [6]	N/A	Reserved	EPA 908	"	"

TABLE II.B., SUITE B

Parameter	AQL (mg/l)[1]	Alert Level [2]	Analytical Method [3]	Sampling Frequency	Reporting Frequency
General Inorganics:				Quarterly	Quarterly
pH (field)	N/A	Calculated[8]	N/A	"	"
Specific Conductance (field)	N/A	Reserved	N/A	"	"
Temperature (field)	N/A	N/A	N/A	"	"
pH (lab)	N/A	N/A	EPA 150.1	"	"
Specific Conductance (lab)	N/A	N/A	EPA 120.1	"	"
Copper [5]	N/A	Calculated	EPA 220	"	"
Sulfate	Reserved	Calculated	EPA 375	"	"
Total Dissolved Solids (TDS)	N/A	Calculated	EPA 160.1	"	"
Iron	N/A	Calculated	EPA 236	"	"
Manganese	N/A	Calculated	EPA 243	"	"
Zinc	N/A	Calculated	EPA 289	"	"

Explanation to footnotes:

1 - All discharge limits (DLs) and aquifer quality limits (AQLs) are in milligrams per liter (mg/L) unless otherwise indicated.

2 - All alert levels are in milligrams per liter (mg/L) unless otherwise indicated.

3 - All analytical methods are EPA methods unless otherwise indicated.

4 - Hardness may be determined using EPA method 130 or as the sum of the Ca and Mg concentrations expressed as $CaCO_3$

5 - All metals and radiochemical analyses shall be conducted for the dissolved fraction (dissolved metals and dissolved radiochemicals) and shall be filtered to .10 microns.

6 - Uranium species and Radon-222 are only required to be tested if the gross alpha particle activity exceeds 15 picocuries per liter (pCi/L). Uranium (total) is the sum of the individual uranium isotopes, U-234, U-235, and U-238.

7 - Bicarbonate may be determined using EPA method 310 or may be determined by calculation.

8 - The alert level for pH shall be set equal to the mean - (1.5)(log units)

N/A means not applicable.

Reserved means that the Arizona Department of Environmental Quality reserves the right to establish discharge limits (DLs), aquifer quality limits (AQLs), and/or alert levels (ALs) at a later date. Any future change of a DL, AQL, and/or AL shall be negotiated with the permittee.

Calculated means that AQLs and ALs shall be established as set forth in PART II.C.2.d.

* - Alert levels for the five polynuclear aromatic hydrocarbons (PAHs) shall be determined using the practical quantitation limits developed from the first year (four quarters) of process solution monitoring in accordance with PART II.H.11.

TABLE III
FACILITY INSPECTION

Parameter	Performance Levels	Inspection Frequency
PLS and Raffinate Ponds Freeboard	No visible cracks or leaks in liner; Minimum three-feet of freeboard; No evidence of seepage	Quarterly Daily
No. 1 and 2 PLS Collection Ponds spillway and overflow channels	Free of obstructions, debris Not overgrown with vegetation	Quarterly
PLS and Raffinate Pond Berm Integrity	No substantial erosion; No evidence of seepage Not overgrown with vegetation	Quarterly or after major rain event (2" in 24 hrs)
PLS and Raffinate Pond Leak Detection Sumps	No impairment of access;	Weekly
Storm Water Diversion Ditches	No substantial erosion Not overgrown with vegetation Free of obstruction, debris	Quarterly
Monitor Well Integrity	Wellhead cap or box locked and secure No visible damage	Quarterly and as sampled

TABLE IV
OPERATIONAL REPORTING SUMMARY

Operational Condition	Specific Reference for Necessary Action
Alert Level Exceedance	PART II.D.1.a
Groundwater Alert Level Exceedance	PART II.D.2.c.(3)
Aquifer Quality Level Violation	PART II.D.2.c.(2)
Accidental Discharge	PART II.D.3
Emergency Response	PART II.D.3.b
Temporary Cessation	PART II.E
Closure	PART II.F
Post-Closure	PART II.G
Major Modification to Facility	PART II.I.4.b
Modification to Permit	PART VI.H.3
Change in Owner or Operator	PART VI.H.4
Bankruptcy or Environmental Enforcement Against the Permittee	PART VI.C

PART V. REFERENCES: PERTINENT INFORMATION

A. References

The terms and conditions set forth in this permit have been developed based upon the information contained in the following:

1. Field Inspection Form(s) dated

2 Permit Application dated November 27, 1991

3. Aquifer Impact Review dated May 4, 1992

4. Plan Review File Number ....

5. Plan Approval by Mining APP Unit dated ....

6. Amendments to above No. 2 dated 2-10-92, 6-18-92, 8-14-92, 9-24-92, 10-9-92, 10-19-92, 11-11-92, 12-18-92, 1-4-93, 1-12-93, 2-11-93, 2-18-93, 4-5-93, 5-14-93, 4-25-94, BADCT Letter from ADEQ.

7. Public Notice dated ....

8. Public Hearing comments, correspondence and any additional supplemental information contained in the permit file.
....
....

9. Other ....

B. Facility Information

1. Facility Contact Person David J. Duncan

2. Address 25,000 W. Avra Valley Road, Marana, Arizona 85653

3. Emergency Telephone Number: (602) 682-2420 (work) and (602) 744-4654 (home)

The Department shall be notified within 30 days of the change in facility contact person.

4. Landowner of Facility Site ASARCO, Incorporated
Address 180 Maiden Lane, New York, NY 10038

C. Definitions

1. **"Alert Level (AL)"** means a numeric value, expressing either a concentration of a pollutant or a physical or chemical property of a pollutant, which is established in an individual Aquifer Protection Permit and which serves as an early warning indicating a potential violation of either an Aquifer Water Quality Standard at the applicable point of compliance, or any permit condition.

2. **"Applicant"** means the owner or operator of the facility.

3. **"Aquifer Protection Permit (APP)"** means an individual, or general permit issued pursuant to A.R.S. Section 49-203 and 49-241 through 251, and A.A.C. R18-9-101 et sec.

4. **"Aquifer Quality Limit (AQL)"** means the maximum amount of a given constituent which the permit conditions allow in the aquifer at the point of compliance. AQLs shall only be established for constituents with primary AWQSs.

5. **"Aquifer Water Quality Standard"** means a standard established pursuant to A.R.S. Section 49-221 and 49-223.

6. **"Areal composite sample"** means a set of samples collected from an area and combined into a single sample. The number and spacing shall be representative of the quality of the accumulated material.

7. **"BADCT"** means the Best Available Demonstrated Control Technology, processes, operating methods, or other alternatives to achieve the greatest degree of discharge reduction determined for a facility by the Director pursuant to A.R.S. Section 49-243.B and D.

8. **"Chain of Custody Form"** is used to maintain and document sample possession for enforcement purposes (User's Guide to the EPA Contract Laboratory Program).

9. **"Department"** means the Department of Environmental Quality.

10. **"Director"** means the Director of Environmental Quality or the Director's designee.

11. **"Discharge"** means, for purposes of the aquifer protection permit program prescribed by A.R.S. Title 49, Chapter 2, Article 3, the addition of a pollutant from a facility either directly to an aquifer or the land surface or the vadose zone in such a manner that there is a reasonable probability that the pollutant will reach an aquifer.

12. **"Discharge Impact Area"** means the potential areal extent of pollutant migration, as projected on the land surface, as the result of a discharge from a facility.

13. **"Discharge Limitation (DL)"** means any restriction, prohibition, limitation or criteria established by the Director, through a rule, permit or order, on quantities, rates, concentrations, combinations, toxicity, and characteristics of pollutants.

14. **"Drywell"** has the meaning ascribed to it in A.R.S. Section 49-331.3.

15. "**Environment**" means navigable waters, any other surface water,groundwater, drinking water supply, land surface, subsurface strata or ambient air, within or bordering on this state.

16. "**Exceedance**" means the detection of a pollutant at levels or concentrations exceeding limits established in this permit.

17. "**Existing facility**" means a facility on which construction began before the effective date of this chapter and which is neither a new facility nor a closed facility. For purposes of this definition construction on a facility has begun if the facility owner or operator has either:

    a. Begun, or cause to begin, as part of a continuous on-site construction program any placement, assembly or installation of a building, structure or equipment; or

    b. Entered a binding contractual obligation to purchase a building, structure or equipment which is intended to be used in its operation within a reasonable time. Options to purchase or contracts which can be terminated or modified without substantial loss, and contracts for feasibility engineering and design studies ,do not constitute a contractual obligation for purposes of this definition.

18. "**Facility**" means any land, building, installation, structure, equipment, device, conveyance, area, source activity or practice from which there is, or with reasonable probability may be, a discharge.

19. "**Groundwater Quality Protection Permit**" means a permit issued by the Arizona Department of Health Services or the Department pursuant to A.A.C. R9-20-208 prior to September 26, 1989.

20. "**Hazardous substance**" means:

    a. Any substance designated pursuant to Section 311(b)(2)(a) and 307(a) of the Clean Water Act;

    b. any element, compound, mixture solution or substance designated pursuant to Section 102 of CERCLA;

    c. any hazardous waste having the characteristics identified under or listed pursuant to A.R.S. 49-922;

    d. any hazardous air pollutant listed under 112 of the Federal Clean Air Act (42 United States Code Section 7412);

    e. any imminently hazardous chemical substance or mixture with respect to which the administrator has taken action pursuant to Section 7 of the Federal Toxic Substances Control Act (15 United States Code Section 2606); and

f. any substance which the Director, by rule, either designates as a hazardous substance following the designation of the substance by the Administrator under the authority described in subdivisions (a) through (e) of this paragraph or designates as a hazardous substance on the basis of a determination that such a substance represents an imminent and substantial endangerment to public health.

21. **"Inert material"** means that which is insoluble in water and will not decompose or leach substances to water, such as broken concrete, brick, rock, gravel, sand, uncontaminated soils.

22. **"Injection well"** means a well which receives a discharge through pressure injection or gravity flow.

23. **"mg/l"** means milligrams per liter.

24. **"Major Modification(s) to a Facility"** means any of the following:

a. A physical change in an existing facility or change in its method of operation that results in a significant alteration in the characteristics or volume of the pollutants discharged.

b. The addition of a process or major piece of production equipment, building or structure that is physically separated from the existing operation and that causes a discharge.

25. **"NPDES Permit"** means a permit issued by the United States Environmental Protection Agency for discharge to the waters of the United States as required by the Clean Water Act, as amended.

26. **"New Facility"** means a previously closed facility that resumes operation or a facility on which construction was begun after the effective date of this chapter on a site at which no other facility is located or to totally replace the process or production equipment that causes the discharge from an existing facility. A major modification to an existing facility is deemed a new facility to the extent that the criteria in A.R.S. 49-243, subsection B, paragraph 1 can be practicably applied to such modification. The following constitute major modification:

(a) A physical change in an existing facility or change in its method of operation that results in a significant alteration in the characteristics or volume of the pollutants discharged.

(b) The addition of a process or major piece of production equipment, building or structure that is physically separated from the existing operation and that causes a discharge.

For purposes of this definition construction on a facility has begun if the facility owner or operator has either:

(i) Begun, or caused to begin as part of a continuous on-site construction program, any placement, assembly or installation of a building, structure or equipment.

(2) Entered a binding contractual obligation to purchase a building, structure or equipment which is intended to be used in its operation within a reasonable time. Options to purchase or contracts which can be terminated or modified without substantial loss, and contracts for feasibility engineering and design studies, do not constitute a contractual obligation for purposes of this definition.

27. **"Operator"** means any person who makes management decisions regarding facility operations governed by this permit.

28. **"Owner"** means any person holding legal or equitable title in any real property subject to this permit.

29. **"Point of Compliance"** means the designated point or points, as determined by the Director pursuant to A.R.S. Title 49, Section 244, at which compliance with Aquifer Water Quality Standards shall be determined.

30. **"Pollutant"** means fluids, contaminants, toxic wastes, toxic pollutants, dredged spoil, solid waste, substances and chemicals, pesticides, herbicides, fertilizers and other agricultural chemicals, incinerator residue, sewage, garbage, sewage sludge,munitions, petroleum products, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and mining, industrial,municipal and agricultural wastes or any other liquid, solid, gaseous or hazardous substances.

31. **"Pre-Mine Activity"** means conventional truck and shovel mining that is performed prior to actual leaching of the ore. This can include placing ore in leach dumps before the start of leaching, stripping overburden, laying solution lines and other operations that are directly associated with bringing the mine into immediate production.

32. **"Recharge project"** has the meaning ascribed to it A.R.S. Section 45-651.5.

33. **"Regulation"** means A.A.C. Title 18, Chapter 9, Article 1, requirements for facilities affecting aquifer water quality.

34. **"Sewage"** means wastes from toilets, baths, sinks, lavatories, laundries, and other plumbing fixtures in residences, institutions, public and business building, mobile homes, water craft, and other places or human habitation, employment, or recreation.

35. **"Sewage disposal system"** means a system for a sewage collection, treatment and discharge by surface or underground methods.

36. **"Surface impoundment"** means a pit, pond or lagoon, having a surface dimension that is equal to or greater than its depth, which is used for the storage, holding, settling, treatment or discharge of liquid pollutants containing free liquids.

37. **"Temporary cessation"** means any cessation or operation of a facility for a period of greater than 60 days but which is not intended to be permanent.

38. "Toxic pollutant" means a substance that will cause significant adverse reactions if ingested in drinking water. Significant adverse reactions are reactions that may indicate a tendency of a substance or mixture to cause long-lasting or irreversible damage to human health.

39. "ug/l" means micrograms per liter.

40. "Underground storage and recovery project" has the meaning ascribed to it in A.R.S. Section 45-802.6.

41. "Vadose zone" means the zone between the ground surface and any aquifer.

42. "Well" means a bored, drilled or driven shaft, pit or hole whose depth is greater than its largest surface dimension.

PART.VI GENERAL CONDITIONS: RESPONSIBILITIES

A. Preservation of Rights

This permit shall not be construed to abridge or alter causes or action or remedies under the common law or statutory law, criminal or civil, nor shall any provision of this permit, or any act done by virtue of this permit, be construed so as to stop any person, this state or any political subdivision of this site, or owners or land having groundwater or surface water rights or otherwise, from exercising their rights or, under the common law or statutory law, from suppressing nuisances or preventing injury due to discharges.

B. Monitoring Requirements

The permittee shall conduct any monitoring activity necessary to assure compliance with any permit condition, with Aquifer Water Quality Standards, and with A.R.S. 49-241 through 49-251:

1. The permittee shall install, use and maintain all monitoring equipment in acceptable condition or provide alternate methods approved by the Department; and

2. the permittee is required to conduct monitoring of a type and frequency sufficient to yield data which are representative or the monitored activity and approved by the Department.

C. Reporting of Bankruptcy or Environmental Enforcement

The permittee shall notify the ADEQ, Aquifer Protection Permit within five (5) days after the occurrence of either:

1. The filing of bankruptcy by the permittee; or

2. the entry or any order or judgment against the permittee for the enforcement of any environmental protection statute and in which monetary damages or civil penalties are imposed.

D. Site Examination

1. On presentation of credentials, the Department may, is reasonably necessary, inspect the facility or an activity used for the generation, storage, treatment, collection or disposal of any waste or pollutant, and where records are kept for the purpose of ensuring compliance with A.R.S. Title 49, Chapter 2, A.A.C. R18-9-101 through 130 and this permit, or to verify information submitted in a permit application, or documented in a permit including any permit conditions.

2. The Department may:

   a. Obtain samples;

   b. analyze or cause to be analyzed any samples either on site or at another location;

   c. take photographs;

   d. inspect equipment, activities, facilities and monitoring equipment or methods of monitoring; or

   e. inspect and copy any records required to be maintained.

3. Any pertinent information required by the permit shall be available for on-site inspection during normal business hours. The owner or operator of the property shall be afforded the opportunity to accompany an ADEQ inspector. Split samples, receipts, and copies of photographs will be provided to the facility owner or operator if the owner or operator requests them at the time the samples(s) is (are) obtained or the photograph(s) is (are) taken as the case may be. A copy of the results of any analyses made of samples, monitoring, or testing shall be furnished promptly to the owner or operator.

4. Inspections shall be conducted pursuant to the appropriate provisions of the Arizona Revised Statutes.

E. Proper Operation

1. The permittee shall at all times operate the facility so as to ensure the greatest degree of discharge reduction achievable through application of the best available demonstrated control technology, processes, operation methods or other alternatives, including, where practicable, no discharge of pollutants as determined in the application process.

2. The permittee shall operate the facility to ensure that pollutants discharged will in no event cause or contribute to a violation of aquifer water quality standards at the applicable point of compliance for the facility, or that no pollutants discharged will further degrade, at the applicable point of compliance, the quality of any aquifer that already violates the aquifer quality standard for that pollutant.

F. Technical and Financial Capability

1. The permittee shall maintain the technical and financial capability necessary to fully carry out the terms of this permit.

2. Any bond, insurance policy or trust fund provided as a demonstration of financial capability in the permit application (R18-9-108.8.c.iii.) shall be in effect prior to any activity authorized by this permit and remain in effect for the duration of the permit.

G. Other Rules and Laws

The issuance of this permit does not waive any federal, state, county or local government rules, regulations or permits applicable to this facility.

H. Permit Actions

1. This permit may be modified, transferred, renewed or revoked under the rules of the Department. The filing of a request by the permittee for a permit action does not stay any existing permit condition.

2. The Director shall issue a public notice of all proposed permit actions pursuant to R18-9-124.

3. Permit Modification

a. Request for modification of a permit shall be made in writing by the permittee, the Department, or any affected person, and shall identify the specific item(s) to be considered for modification and the facts and reasons which justify the request.

b. The permittee may be required to submit additional information pursuant to A.A.C. R18-9-108, including an updated permit application.

c. The Director may modify an individual Aquifer Protection Permit if the Director determines any one or more of the following:

(1) That material and substantial alterations or additions to a permitted facility justify a change in permit conditions;

(2) that the discharge from the facility violates or could reasonably be expected to violate any Aquifer Water Quality Standard;

(3) that rule or statutory changes have occurred, such as to require a change in the permit; and/or

(4) that there has been a change of an applicable point of compliance.

d. With written concurrence of the permittee, the Department may make minor modifications to a permit for any of the following reasons without giving public notice or conducting a public hearing:

(1) To correct typographical errors;

(2) increase the frequency of monitoring or reporting;

(3) change an interim compliance date in a compliance schedule if the permittee can show just cause and that the new date does not interfere with the attainment of a final compliance date requirement;

(4) change construction requirements, if the alteration complies with the requirements of these rules and provides equal or better performance; or

(5) replace monitoring equipment, including wells, if such replacement results in equal or greater monitoring effectiveness.

4. Permit Transfer

a. The Director may transfer an individual Aquifer Protection Permit if the Director determines that the proposed transferee will comply with ARS 49-241 through 49-251 and A.A.C. Chapter 9, Article 1, regardless of whether the permittee has sold or otherwise disposed of the facility, until the Director transfers the permit.

b. The proposed transfer or and the transferee shall notify the Department within ten days after any change in the owner or operator of the facility. The notice shall include the name and signature of the transferor owner or operator, the name and signature of the transferee owner or operator; and the name and location of the facility.

c. Information required in R18-9-108.A.1, 2, 3 and 6; B.7, 8, and 9; and D. shall be submitted about the Transferee prior to transfer of the permit.

5. Permit Revocation and Suspension

The Director may suspend or revoke this permit for any of the following reasons:

a. Noncompliance by the permittee with any applicable provision of Title 49, Chapter 2, Article 3 or the Arizona Revised Statutes, A.A.C. Title 18, Chapter 9, Article 1 or permit conditions;

b. the permittee's misrepresentation or omission of any fact, information or data related to the permit application or permit;

c. the Director determines that the permitted activity is causing or may cause a violation of any Aquifer Water Quality Standard; or

d. a permitted discharge has the potential to cause or will cause imminent and substantial endangerment to public health or the environment.

I. Confidentiality of Information

1. Any information submitted to or obtained by the department pursuant to A.R.S. 49-243 may be available to the public unless it is designated confidential. Information or a particular part of the information shall be considered confidential on either:

a. A showing, satisfactory to the Director, by any person that the information, or a particular part of the information, if made public, would divulge the trade secrets of the person; or

b. a determination by the attorney general that disclosure of the information or a particular part of the information would be detrimental to an ongoing criminal investigation or to an ongoing or contemplated civil enforcement action under A.R.S. Title 49, Chapter 2 in Superior Court.

2. Criteria for Determining Confidentiality

a. A confidentiality claim has been made at the time the information was submitted or obtained;

b. the facility owner or operator has shown that reasonable measures have been taken to protect the confidentiality of the information and intends to continue to take such measures;

c. the information is not, and has not been, reasonably obtainable without the facility owner or operator's consent by persons other than governmental bodies by use of legitimate means, other than discovery based on a showing of special need in a judicial or quasi-judicial proceeding;

d. no statute or rule specifically requires disclosure of the information; and

e. the facility owner or operator has shown that disclosure of the information is likely to cause harm to its competitive position.

3. Financial information required in the permit or permit application will be held confidential. Notwithstanding, the Director may disclose any records,reports or information obtained from any person in regard to this permit, including records, reports or information obtained by the Director or Department employees, to:

a. Other state employees concerned with administering A.R.S. Title 49, Chapter 2, or if the records, reports or information are relevant to any administrative or judicial proceeding under that chapter; and/or

b. employees of the United States Environmental Protection Agency, if such information is necessary or required to administer and implement or comply with the Clean Water Act, and Safe Drinking Water Act, CERCLA or provisions and regulations relating to those acts.

4. Claims of confidentiality for the following information shall be denied:

a. The name and address of any permit applicant or permittee;

b. the chemical constituents, concentrations and amounts of any pollutant discharge; or

c. the existence or level of a concentration of a pollutant in drinking water or in the environment.

J. Violations; Enforcement

Any person who owns or operates a facility contrary to the provisions of ARS Title 49, Chapter 2, who violates the conditions specified in the A.A.C. Title 18, Chapter 9, Article 1, or this permit, is subject to the enforcement actions prescribed in A.R.S. Title 49, Chapter 2, Article 4 or the Arizona Revised Statutes.

SILVER BELL (F) PIMA CO.

HMC

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

Fife Symington, Governor   Edward Z. Fox, Director

NOTICE OF THE PRELIMINARY DECISION TO ISSUE AN INDIVIDUAL AQUIFER PROTECTION PERMIT

Pursuant to Arizona Administrative Code, Title 18, Chapter 9, Article 1, the Director of the Arizona Department of Environmental Quality intends to issue an individual Aquifer Protection Permit to the following applicant(s):

Public Notice No. 24-94AZAP   On or about June 15, 1994
ASARCO,INC- SILVER BELL UNIT Site
ASARCO Incorporated
Silver Bell Unit
25,000 W. Avra Valley Road
Marana, AZ 85653

Aquifer Protection Permit No. P-100510

The ASARCO,INC- SILVER BELL UNIT site is located approximately 17 miles west of Marana, Arizona in Pima County, Arizona, over groundwater of the Tucson A.M.A. Basin and the Pinal A.M.A Basin in Township 11S, Range 08E, Sections 32,33, and 34, and in Township 12S, Range 08E, Sections 3, 4, 5, 10, 11, and 12, -Gila and Salt River Base Line and Meridian. Latitude 32° 22' 56.0" North and Longitude 111° 27' 43.0" West.

The proposed facility is a copper leaching operation consisting of two leach dumps and in-situ leaching of rubblized ore within the existing Oxide and El Tiro open pits, and in the proposed West Oxide and North Silver Bell open pits. Copper ore will be leached with a dilute sulfuric acid solution. Solutions will be collected in lined impoundments and pumped via pipelines to a solvent extraction-electrowinning plant for processing. Solutions stripped of copper will be recycled into the dump and rubble leaching circuits. The facility will process approximately 6,700 gallons of solution per minute and generate approximately 50 tons of copper of 99.99% purity per day.

The areas designated for rubblized leaching will be fractured using controlled, close-spaced blasting to create zones of fractured rock and high hydraulic conductivity. Controlled blasting will create a surface along which leach solutions will flow and drain to the collection sump in the bottom of the open pits immediately below the rubblized zones. The high contrast in hydraulic conductivity between the rubblized zone and the underlying bedrock will result in minimal losses of leach solution from the leach zones.