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VEGETATIVE STABILIZATION OF TAILINGS DISPOSAL BERMS AT PIMA MINING COMPANY

By

Kenneth L. Ludeke
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Tucson, Arizona 85713

Presented at the 1972 Mining Convention of the American Mining Congress, San Francisco, California, September 17-20.

F8

PIMA MINING COMPANY

The Pima Mine lies 20 miles southwest of Tucson, Arizona and 45 miles north of the Mexican border. Pima is managed and 50 percent owned by Cyprus Mines Corporation. Union Oil of California and Utah International, Inc. each have a 25 percent interest. Discovered in 1950 by geophysical methods, it was originally conceived to be operated as a small, high grade underground operation. However, Pima started production in January 1957 as a small open pit operation with an expected life of ten years at a concentration rate of 3,000 tons per day. As a result of four expansions, the last being completed early in 1972, the plant capacity has grown to a rate of approximately 54,000 tons per day.

INTRODUCTION

With the greatly increased capacity of the concentrator, tailing disposal ponds have had to become larger and required that they be located nearer the interstate highway going from Tucson to the border city of Nogales, Arizona.

In order to maintain the natural desert beauty, Pima embarked on a voluntary program of cultivating and experimental planting of various types of plants. With this experimental program the most promising features were expanded so that some 85 acres now available along the berms have been planted. Additional acreage will be planted to coincide with the growing season.

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SOCIETY OF MINING ENGINEERS
of AIME
345 EAST 47TH STREET, NEW YORK 17, N.Y.

PIMA, A NEW FACE

George A. Komadina
Assistant Resident Manager
Pima Mining Company
Tucson, Arizona

This paper is to be presented at the Annual Meeting of the American Institute of Mining, Metallurgical and Petroleum Engineers, Los Angeles, California, February 19-23, 1967.

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REVISED ABSTRACT

Pima Mining Company has recently completed their expansion tripling the plant capacity to 18,000 tons per day and now is in the process of expanding to 30,000 tons per day with completion scheduled for the summer of 1967.

This paper briefly discusses the additions to the mining department and support areas with a more detailed report on the complete new crushing plant and additions to the concentrator.

The crushing plant includes a 54-inch gyratory crusher, three 7-foot standard and seven 7-foot short head crushers along with necessary screens, feeders, and conveyor belts to produce a minus 1/2-inch rod mill feed.

The concentrator consists of ten milling sections, each containing one 10-foot by 16-foot rod and two 10.5-foot by 13-foot ball mills, classification is done with cyclones. Pulp from each section is floated in 50 cells of 66-inch Fagergren flotation machines to produce a rougher concentrate which is cleaned in six stages of Denver cleaners to produce a final concentrate. The various mill products are thickened with disposal made in conventional manner. Plant instrumentation is discussed in the paper.

67-12-3

PIMA, A NEW FACE

by

George A. Komadina
Assistant Resident Manager
Pima Mining Company
Tucson, Arizona

General:

From a modest beginning in 1957 with one grinding section handling 3,000 tons per day, Pima Mining Company, Tucson, Arizona, has steadily expanded. In July, 1966, work was completed that allowed the concentrator to treat in excess of 18,000 tons per day. Almost immediately Pima was embarked on another program that will see the plant increase in size to 30,000 tons per day sometime during the summer of 1967.

The story of Pima has been one of repeated expansions as additional low-grade ores were developed, and operating economics dictated handling larger masses of material. Early in the life of Pima it was known that a mineralized area was present on the flanks of the high-grade ore body. Systematic drilling showed that a low-grade copper ore body existed. After many months of engineering studies a picture was developed that reduced the unknowns to one that would allow Pima to join other large scale low-grade copper operations in the Southwest.

This paper covers the expansion from two milling sections reported in the June, 1965, issue of Mining Engineering to the present six and then to the ten sections which will be operating during the summer of 1967. Design of the ten milling section plant was laid out in sufficient detail at the six section level so that an expansion could take place with a minimum of interruption to the operating 18,000 TPD plant. Basic design and construction is being repeated in the four new milling sections with some modifications developed during the past eight months of shakedown operations. Conveyor belts and gear boxes were so sized that up to 30,000 tons per day could be handled without replacing the complete units at a later date. Some motor changes are now being made to allow for increased belt speeds needed to carry the new designed load.

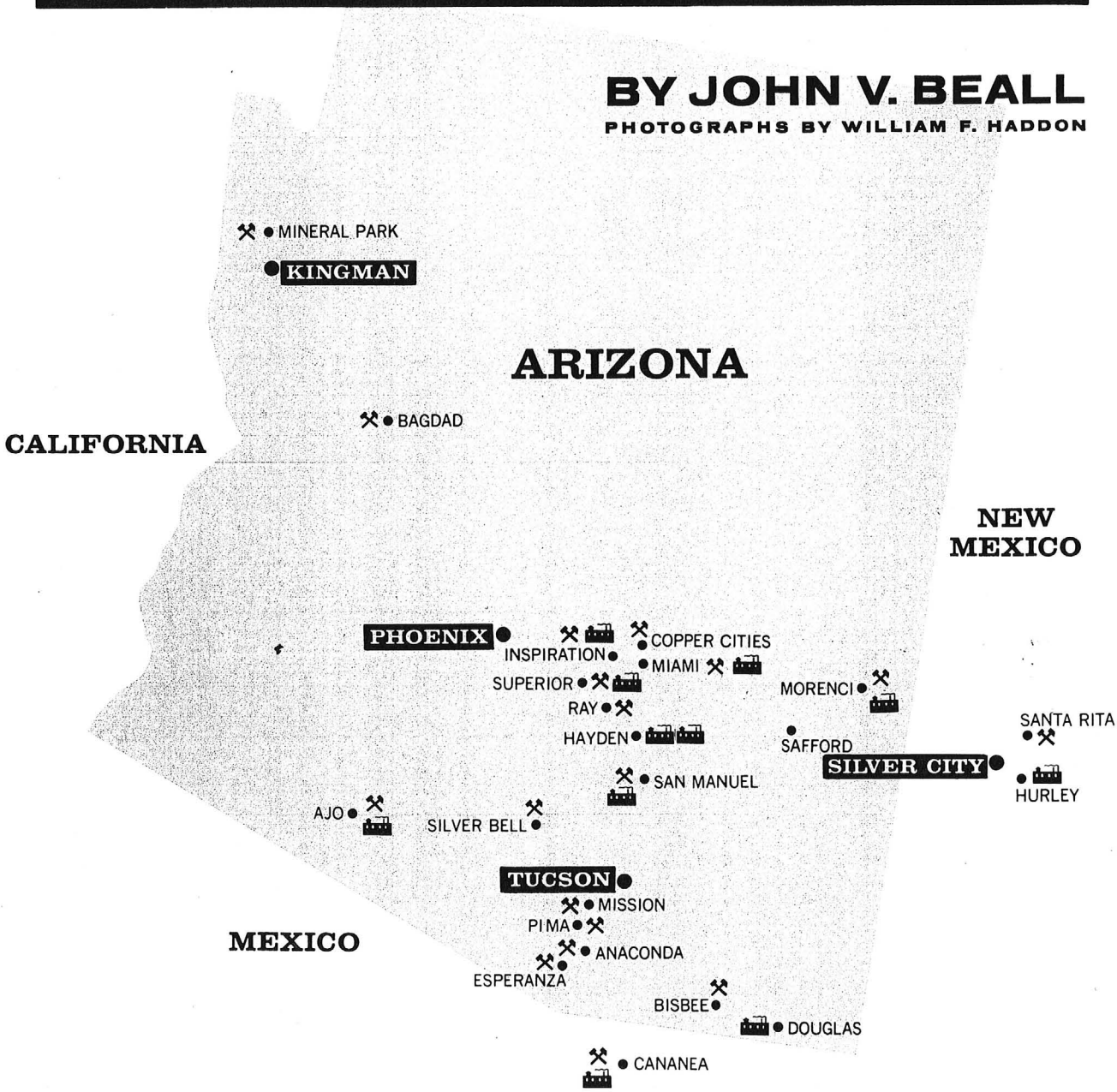
Lima Mining Co.

SOUTHWEST COPPER

A POSITION SURVEY

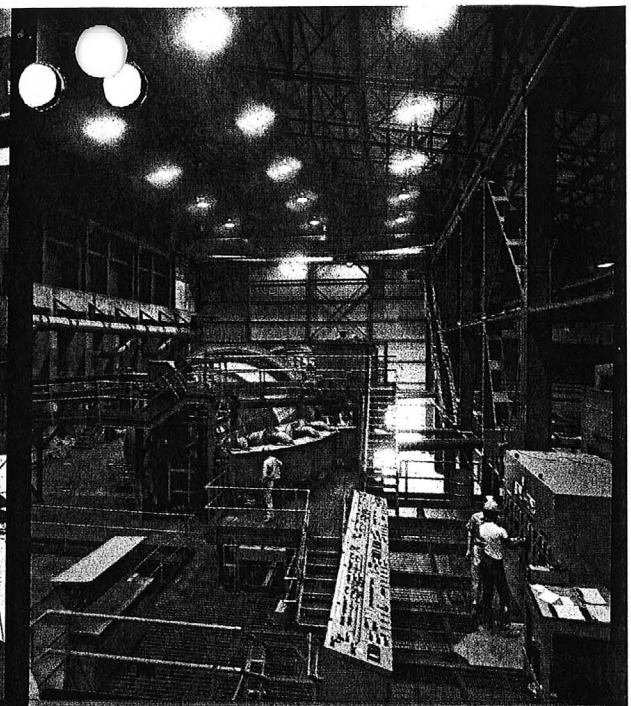
BY JOHN V. BEALL

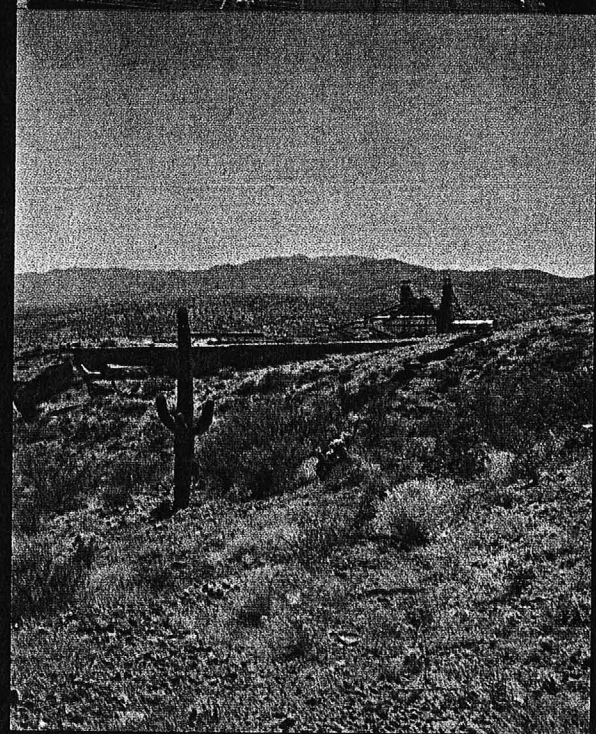
PHOTOGRAPHS BY WILLIAM F. HADDON



When the mineral seekers came, they brought romance, excitement and, too often, transitory riches. It has been so for uncounted centuries. While the rich ore lasted, living was high and money flowed—mostly out of town. The whole creation was like a circus. The headframe went up like the center pole of the big top. The reduction works was an ingenious affair; an opportunity for self-expression by the mining engineer on the job. When the high grade gave out or the bottom dropped out of the market, the whole show folded. Machinery was scavenged for the next location. About all that was left were the raw footings, like giantsteps on the hillside; and the headframe above the silent diggings. Mostly, the people went away too.

Arizona Territory was like that at the turn of the century. It can still happen. But, in copper, the age-old pattern has been disrupted. From Mineral Park in the northwest to Chino in the east and Cananea in the South, a growing number of companies have emerged—large, stable, productive. Southwest copper is truly a mighty industry, accounting for one fifth of world new copper production. In this period of scientific development, changes are fast, often dramatic. But even mining engineers, or possibly more so because they have an intimate knowledge of



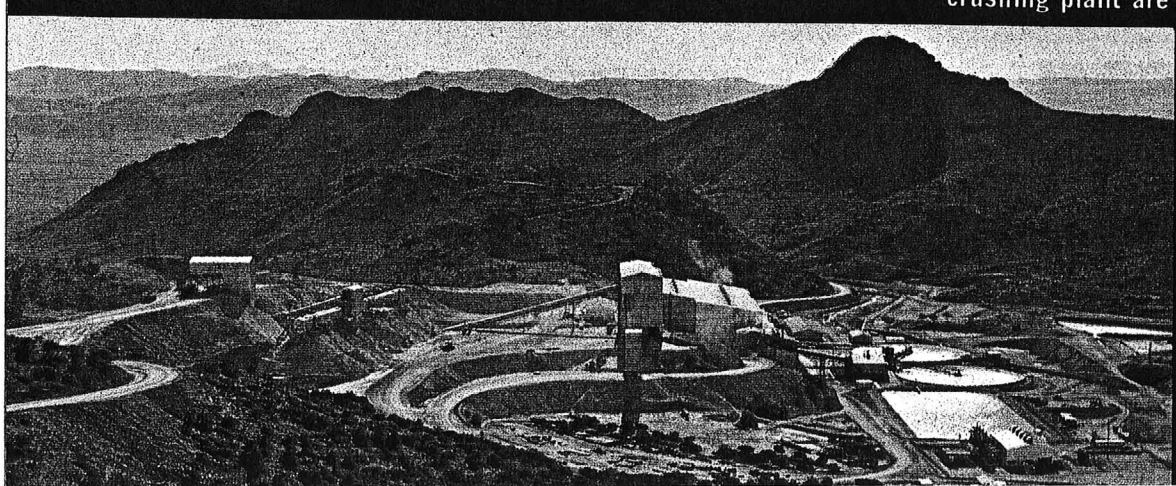


Top: Bagdad's concentrator receives ore from open pit via enclosed conveyor at left. Headframe is relic of former underground mining.

Bottom: Airborne view of Christmas mine shows headframe, 4000 tpd concentrator, tailing area and offices set in rugged Arizona terrain.

Top: Grinding bay at Mineral Park shows autogenous mills, cyclone arrangement and control panel.

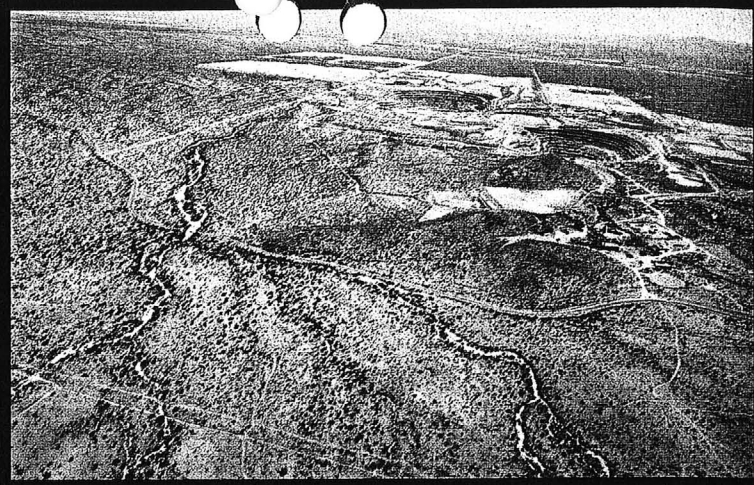
Bottom: San Manuel twin ore shafts and crushing plant are beyond subsidence area.



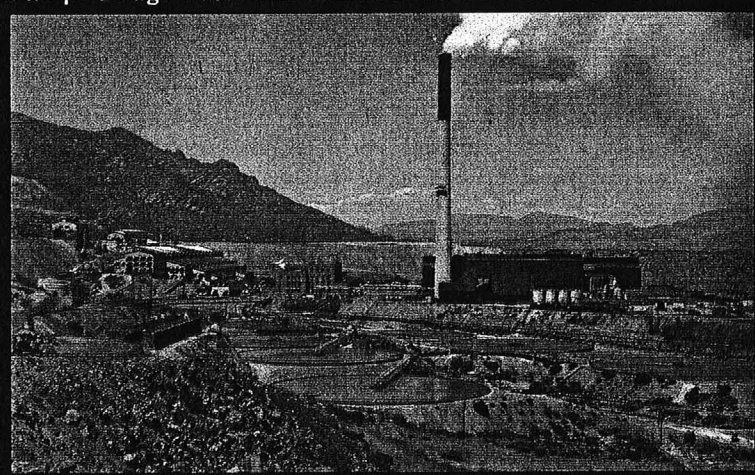
Duval's Mineral Park concentrator went on steam in late 1964. See interior view above.

Inspiration pit butts vat leaching plant and shops. Residues from leaching go by rail to concentrator.

Mission pit, left, nearly touches Pima. Old Mineral Hill mine at right middle.



Phelps Dodge's Morenci concentrator and smelter.

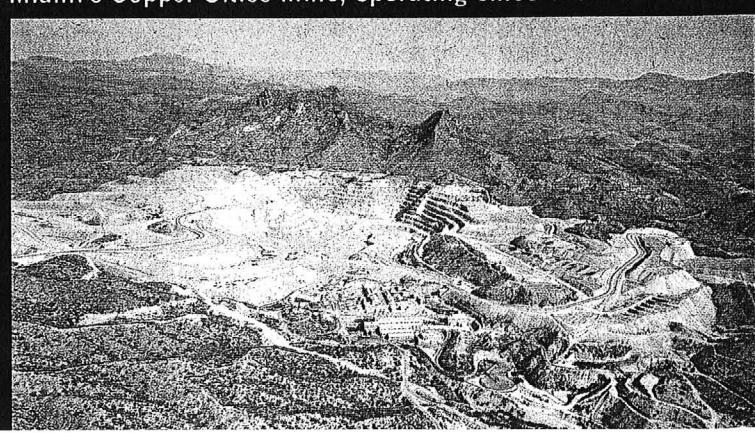


Lavender pit at Bisbee supplies bulk of ore to plant.

Cananea pit in Mexico, is 1 of 2 operating.

Ray pit sends ore 23 miles to Hayden reduction works.

Miami's Copper Cities mine, operating since 1954.



the industry, fail to appreciate the evolutionary changes that have shaped Southwest copper into what it is today.

Southwest copper growth seems to divide into two periods; one from shortly after 1900 until 1930 and a second beginning in 1940 and continuing into the present. The early period was embued by the idea of large scale mining and sparked by development of blockcaving, rail haulage pits and flotation; the second by an equipment revolution that lowered costs in mine and plant and cut sharply into the lead time for plant construction when large amounts of capital would be tied up without financial return. Other important factors have been the recovery of by-product molybdenum and improvements in exploration techniques such as those which permitted the discovery of the Pima district by Walter Heinrichs, Jr. and Robert Thurmond.

In 1900 there was no concentrator bigger than 500 tpd in the region. In this survey the smallest now is 4000 tpd, there are eleven 12,000 tpd or greater and the biggest is 58,000 tpd at Morenci. The old makeshift plants have been superceded by packaged sections that can be expanded at will. Leaching of soluble copper minerals was developed early and has been greatly extended. But it was replacement of vanners and tables by flotation that gave the great boost to copper recoveries thereby bringing in the large low grade porphyries.

Selective mining has all but ceased to be a copper source of consequence in the Southwest. Magma, at Superior, is still mining high grade ore from dwindling reserves. Cananea ceased underground mining a month or two ago. Christmas strives to lower the cut-off by mechanization and is therefore somewhere between a high grade selective mine and the mass producting method of blockcaving. Bisbee is still producing from underground to sweeten the mill heads as well as high grade, direct-smelting oxides. From a tonnage standpoint, the only big underground producer is San Manuel which carries on the great blockcaving methods developed at Inspiration, Miami and Ray. However, if underground mining were in search of a champion, there is none better than San Manuel weighing at 39,000 tpd from underground!

The great source of copper now is from the expanding number of open pit mines. As one engineer described them; "the great waste mines." Since the amount of waste produced is greater than the ore and the planning of waste removal determines the available ore, the expression is quite accurate. Such great pits as Morenci, Chino and New Cornelia started early with open cut methods because of large dimensions that were amenable to rail haulage, then the most feasible system for mass movement of bulk materials. Many of the other mines that are operating today on smaller deposits were made possible by the development of truck haulage. Strides in heavy equipment manufacture have also brought in deposits that suffered from the double handicap of low tenor in copper and the necessity of deep stripping before mining.

Growth of the mines and present status is given in the table accompanying this article. The numerous plant additions described in the status reports on each property which follow bespeak the healthy growth position of Southwest copper.

At the last count, made last summer, there were 45 companies doing exploration work in Arizona. The march of progress goes on. Off by Safford, there are vast reserves of low grade copper in which Bear Creek, Phelps Dodge and United Nuclear have or are performing exploration. But down just south of Pima, a new giant is being exposed for productivity. Now the great difference from the old days can be seen. Southwest copper employs 18,000 men who have founded stable communities in support of an enduring industry.

Anaconda

South of Pima in the Twin Buttes area, The Anaconda Co. began a giant stripping operation two months ago. It will take 4 years to complete, in which 165 million tons of alluvial overburden will be removed. Anaconda has been testing areas leased from Banner Mining Co. for about 2 years and the Twin Buttes project has been the major outcome.

A 900 ft shaft was sunk and drifts and cross-cuts driven into the orebody to take bulk samples now being tested in a 200-ton pilot plant situated at the old Mineral Hill mine near Pima. Anaconda cannot tell about the flowsheet or size of the plant that will be constructed until tests are complete.

In the meantime, the Company moved swiftly and surely into what may be the world's biggest pre-mine stripping job. Removal of 165 million tons will take the surface down 460 ft to bedrock. The first units of a $4 million fleet of heavy equipment are in operation. Scrapers of 80 ton capacity are being used for the initial cut down to 150 ft. After that a 60-in. slope belt will be added in sections. It will travel at 960 fpm to carry overburden material delivered by scraper and discharged to a truck loading hopper at the rate of 6000 tph. Bottom dump trucks of 100 ton capacity will carry the overburden to the tailing area where it will be used to form the retaining dam. When fully installed the conveyor will be 11,000 ft overall with the main section, a single conveyor 8300 ft long. This is said to be the longest known single overland belt conveyor used in open pit mining in the U.S.

By 1970, Anaconda's Twin Buttes mine is scheduled to be in production.

Cananea

After 65 years of underground mining, Cananea discontinued subsurface mining this year. Operations are now centered on open pit methods. The Company has some experience at this having already exhausted two pits. Ore is presently being extracted from the Sonora Hill deposit and La Cananea pit has been

(*Continued on page 84*)

DUMP LEACHING—AN EXPANDING SOURCE OF COPPER

On this page and the succeeding two pages of photographs attention is focused on the leaching of low-grade copper ore on mine dumps. This practice is expanding rapidly and may ultimately lead to large scale "chemical mining."

Leaching is still in the "art" stage because there is little precise knowledge of the chemistry. Although the practice is not new, it is only recently that intensive experimentation has begun with a view to lifting the process out of the category of a minor sideline and elevating it to an integral part of copper producing operations. For example, at Chino leaching has been dovetailed into overall mining plans by expanding the leaching operation, putting higher grade material on the leaching dumps, and raising the cut-off grade of ore that is sent to the concentrator.

It is quite possible that as experimental work progresses, dumps will be shattered by explosive charges for controlled percolation of solutions that may be injected under pressure and fortified with catalysts and solvents to achieve greater production in a shorter period of time. It is probable that the future will see more leaching in place than at present.

Current leaching practice is an approximation of natural processes, in which old dumps or low grade ore, considered waste, is irrigated with water, in some cases souped up with acid. The water percolates through the dump dissolving copper as it descends until the solution is trapped at the bottom where it drains to catchment reservoirs and is then delivered to tanks where it replaces iron placed there to precipitate the copper. Operating data given in table below show variations in different orebodies.

For all practical purposes, leaching is performed by sulfuric acid and ferric sulfate by oxidizing copper minerals to soluble copper sulfate. Where there is sufficient pyrite in the waste dump, leaching may be performed with natural water, the acid being formed by reaction with pyrite. The general equations given below approximate the reactions which are thought to take place for the minerals that are amenable to the process. Chalcopyrite, an important ore mineral, is not significantly leached by the solutions. Certain bacteria, utilizing iron and copper in their metabolism, are oxidizing agents which catalyze the leaching process. Other catalysts and solvents are coming on the market which may economically increase the efficiency of leaching. Precipitation of copper from the pregnant solution may see a change in method due to the high cost of iron scrap.

Azurite

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

Chalcocite

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

Covellite

$$CuS + Fe_2(SO_4)_3 = CuSO_4 + 2FeSO_4 + S$$

Cuprite

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

Chrysocolla

$$CuSiO_3 \cdot 2H_2O + H_2SO_4 = CuSO_4 + SiO_2 + 3H_2O$$

Malachite

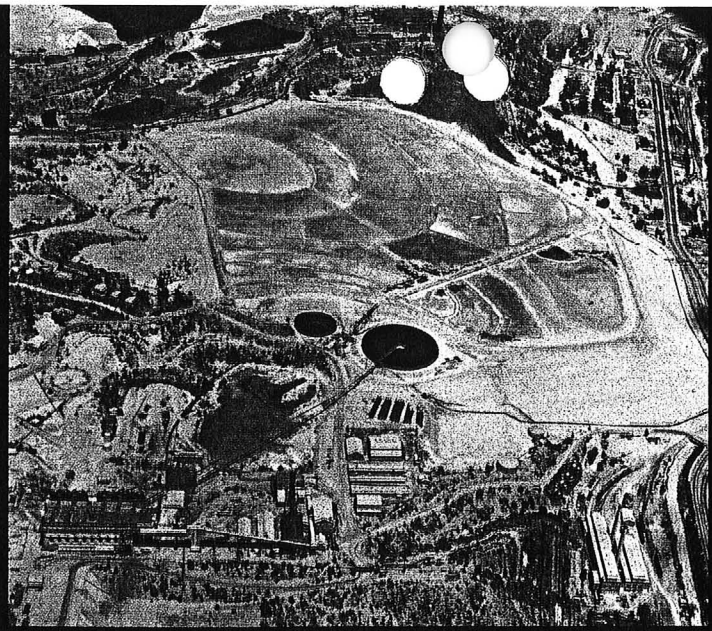
$$Cu_2(OH)_2 \cdot CO_3 + 2H_2SO_4 = 2CuSO_4 + CO_2 + 3H_2O$$

Pyrite

$$2FeS_2 + 2H_2O + 7O_2 = 2FeSO_4 + 2H_2SO_4$$

DUMP LEACHING DATA	CANANEA	COPPER QUEEN	RAY	CHINO	INSPIRATION	BAGDAD	ESPERANZA
Qty. of sol. circulating, gpm	1200	2100	5000	11,000	n.a.	3300	1000
% Cu in dump (range)	0.2-0.4	0.3	n.a.	0-0.5	n.a.	0.25-0.75	0.15-0.4
pH of sol. to dump	2.75	3.5	2.1-3.5	3.5	2.64	2.00	4.5
Fe^{++} in sol. to dump, gpl	20.0	10	1.2-2.4	3.6	4.96	3.80-4.20	1.44
Fe^{+++} in sol. to dump, gpl	2.2	nil	0.06	.1	0.50	.10-.20	trace
Cu in sol. to dump, gpl	0.15	nil	trace	.1	0.24	0.02	trace
pH of pregnant sol.	2.0	2.0	2.0-2.5	2.5	1.88	2.3-2.5	2.5
Fe^{++} in pregnant sol., gpl	6.0	3.5	0-0.96	1.0	3.34	.02-.05	trace
Fe^{+++} in pregnant sol., gpl	12.0	3.0	0.24-1.80	1.0	2.73	1.80-2.00	0.24
Cu in pregnant sol., gpl	1.50	1.4	0.24-3.60	1.8	1.877	1.10-1.30	1.2
Quantity of acid additions, lb/ton of sol.	none	none	n.a.	3.3*	9.82	14-16	none
Operng. range of Cu in preg. sol., gpl	1.30-2.50	1.1-2.4	0.60	1.2-2.4	n.a.	1.3-1.10	n.a.
Solution loss, %	5.0	1	n.a.	5-6	6.65	7	25-30
Iron consumption, tons/ton Cu ppt	4	2.5	n.a.	1.5	2.52	1.8	1.35
Length of dump rest, months	6	12	n.a.	4	n.a.	2½	none

*Testing



Iron stains show up Miami's leach areas.

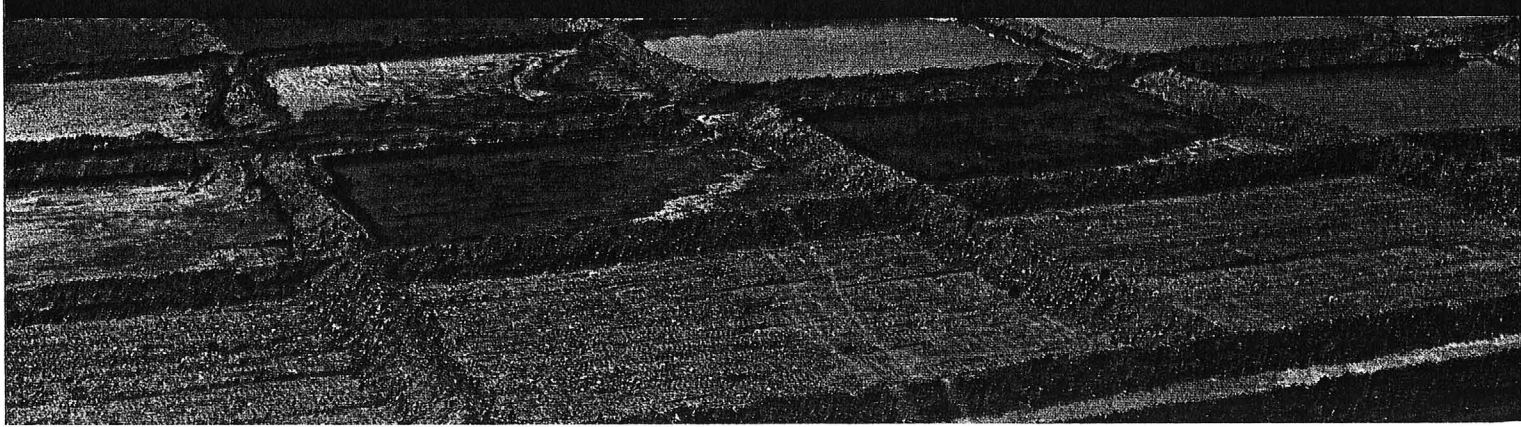
Copper-bearing solutions collect below Castle Dome terraces.

Silver Bell leaching ponds with El Tiro pit behind.

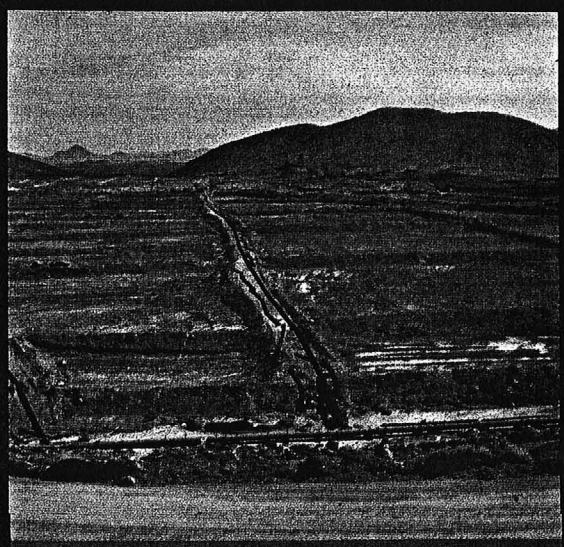
Top: Esperanza ponds show iron salts accumulations.

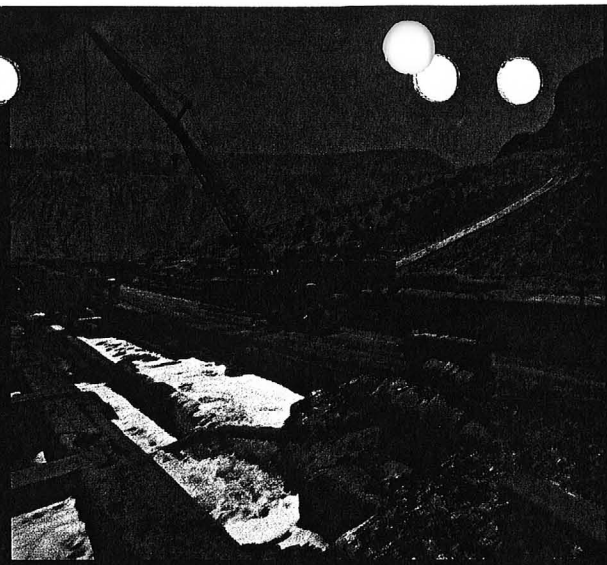
Right: Solution distribution lines feed sprays.

Below: Iron, eventually sealing dumps, must be ripped.

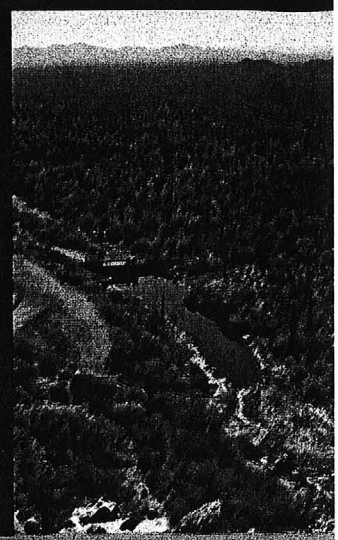


Ponds atop Bisbee dumps in rest[illegible]iod

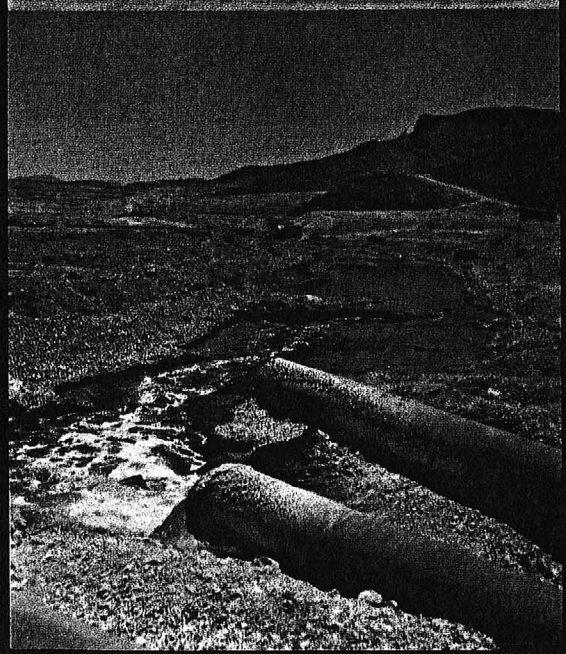




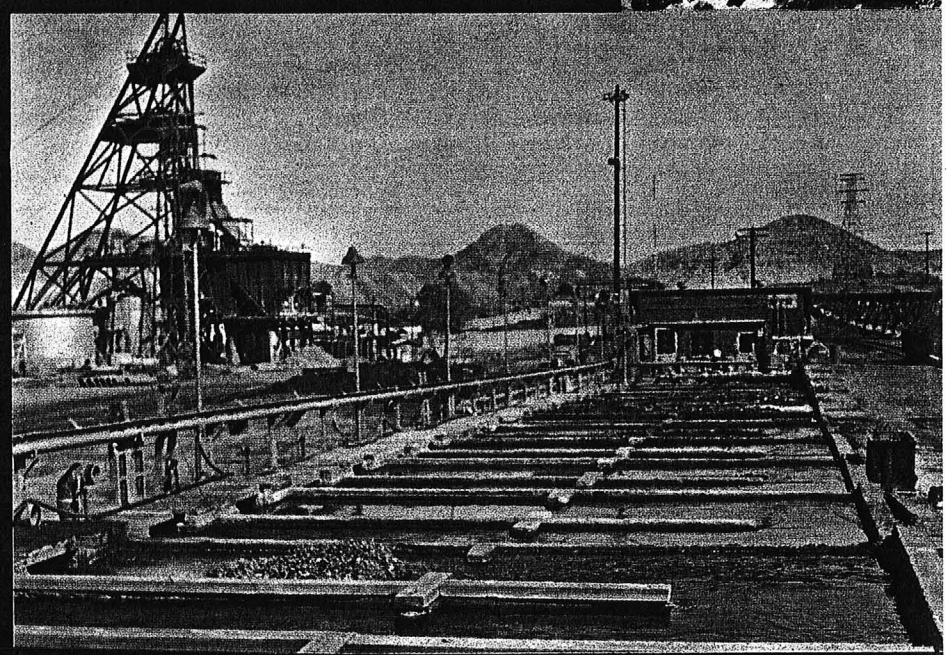
Gathering pond for solutions from dumps.



Chino's precipitation and piping to leach areas.

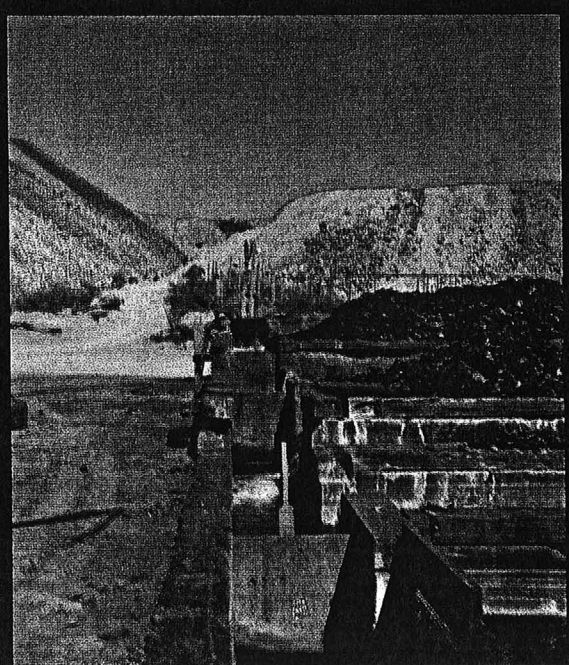


Gravity flow can reduce pumping costs.



Circulating solutions deposit their copper on iron at Bisbee.

Shredded can supply ahead of ppt/tanks.



Heavy scrap supplements shredded cans in Bisbee's precipitation.

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345 EAST 47TH STREET, NEW YORK 17, N.Y.

THE FUTURE DEVELOPMENT OF PERSONNEL FOR OPEN-PIT MINING

H. E. Rudi
Director of Personnel and Labor Relations
Pima Mining Company
Tuscon, Arizona

This paper is to be presented at the SME Fall Meeting -
Rocky Mountain Minerals Conference, Phoenix, Arizona
October 7 to 9, 1965

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The advent of open pit mining permitted the development and processing of minerals never before thought possible. New equipment was needed; new techniques were devised; new methods were called for. This development and acquisition of new techniques, methods and equipment did not, however, stir the souls of our industry and educational leaders sufficiently to a recognition of the problem of people, especially the future development of the people needed in open-pit mining. The people problem has been and will be with us as long as there are two of them. The development of people will be required for the same reason.

The problem of developing future personnel for open-pit mining is not what must be developed; that is known to all of us and can be briefly stated as "more and better of everything." As I see it, the real problem lies in determining (1) what personnel are really critical, (2) why are they critical and (3) how can we develop them.

What personnel are really critical

After considerable thought, the determination of what is critical is not at all startling. They fall into four broad groups, the same four groups we see in all reports which have studied the problem - management, professional, technical and skilled. What is startling is the fact that we know it but haven't really done much about it. Since World War II, the electronics industry has so captured the imagination and recruit of our engineering schools, that we in the mining industry have just sort of capitulated to the so-called "sophisticated glamour boy."

But, I think, we have now begun to fight back; if not fight, then at least we have begun to "join em." We are recognizing that electronic data processing and programming and computers, like TV and freeways, are here to stay. We are recognizing that an upgrading and return to "glamourization" are necessary if we are to compete.

The basic solution to the problem will, I feel, lie in the closer interrelationships between industry and education; between industry and the people themselves.

Why are these groups critical

It is not an easy matter to determine why the development of management, professional, technical and skilled personnel is critical. We know we need them; but that is not the answer. The answer, I believe, is in the rapid change of concepts in all four groups. To cite one example, the rapid development of the concept of the Great Society has caused all of you to readjust some of your thinking about your future. Those of you in management may find it more difficult to devote as much time to the management of your open-pit mine as compared to the time devoted to affairs created by the Great Society. Those of you who are not yet in management will change

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J. ALLEN OVERTON, JR., EXECUTIVE VICE PRESIDENT

PIMA MINING COMPANY'S EXPANSION PROGRAM*

by

M. D. MARTIN
Chief Mining Engineer

G. A. KOMADINA
Assistant Manager

and

J. F. OLK
Mine Superintendent

Pima Mining Co.

Tucson, Arizona

* Presented at the 1965 Mining Show, American Mining Congress, Las Vegas, Nevada, October 11-14.

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INTRODUCTION

Discovered in 1950 by geophysical methods and originally conceived of as a small tonnage, high grade underground operation, Pima Mining Company, 22 miles southwest of Tucson, Arizona, actually started operation on 1 January 1957, as a fairly small, high grade open pit operation with a projected life of less than ten years. The original mill capacity was 3,000 t.p.d. and the planned pit was a small, deep and steep one worked by small shovels and trucks in conjunction with an inclined skip system.

It is now almost nine years since the first concentrates were produced. During 1963, the capacity was doubled to 6000 t.p.d., and today Pima is rather more than halfway through an expansion program which increases the mill capacity from its present 6000 t.p.d. to 18,000 t.p.d. and converts the mining operation entirely to large electric shovels and trucks. At the same time the projected life, at this much higher tonnage rate, is more than three times what was originally conceived. What then has happened in the last ten years to make the original planning decisions look so out-dated?

It is only stating the obvious to say that the ore reserves have been vastly increased. Initially, there was considerable doubt whether the mineralized ground to the east of the present pit did or did not constitute ore reserves. This mineralized zone has been known about since 1956, when the first diamond drill hole was put down in the area, but the task of showing that this mineralization could be mined at sufficient profit to pay off a large plant in a reasonable length of time and then continue to show a reasonable rate of return thereafter has been an arduous one. The first part of this paper will describe this task.