CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
1520 West Adams St.
Phoenix, AZ 85007
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

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GEOLOGY OF THE HELVETIA COPPER DEPOSIT — ARIZONA

S. A. Anzalone

ASARCO Incorporated
Tucson, Arizona

R. L. Brown

ASARCO Incorporated
New York, New York

For presentation at the SME Annual Meeting
Phoenix, Arizona — February 24-27, 1992

eology of the Helvetia Copper Deposit Arizona

The Helvetia copper deposit is a large ıdeveloped Laramide porphyry copper system ɔcated in the Santa Rita Mountains, Pima County, Arizona. This porphyry copper system consists of four areas of copper mineralization: Rosemont, Peach-Elgin, Broadtop Butte, and Copper World. Asarco refers to the four areas collectively as the "Helvetia Deposit". Mineralization and alteration are primarily contact pyrometasomatic, and zoning of hydrothermal alteration and sulfide mineral assemblages are similar to those observed at the Twin Buttes and Mission copper mines located approximately 32 km west of Helvetia. Asarco acquired the Helvetia Deposit in 1988 and has continued the exploration and development effort since then.

A considerable amount of excellent geological work has been completed in the area but little information has been published on developments since the mid-1950's. The geology of the deposit as developed by numerous geologists over the past 75 years and the large, bulk tonnage low grade copper deposits outlined in recent years will be briefly reviewed in this paper.

Location

The Helvetia copper deposit is located approximately 50 km southeast of Tucson, Arizona, in the northern Santa Rita Mountains (Figure 1). It lies within the Basin and Range Physiographic Province at elevations ranging from 1402 m to 1890 m.

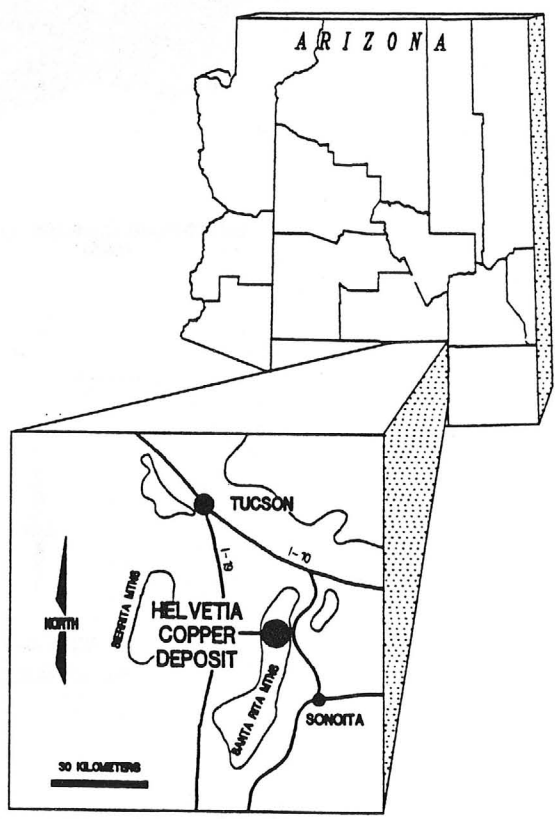
Exploration and Mining History

Copper mineralization may have been discovered in the Helvetia district prior to the Civil War, but no records are available for these early discoveries. The district has had a relatively small production of copper ore principally from underground mines. In the late 1880's copper ore from the district was treated at the Columbia Smelter, located on the west side of the Santa Rita Mountains, and the Rosemont Smelter, located on the east flank of the same range near the Rosemont Camp (Creasey, 1955). In 1903 the Helvetia Copper Company began operation and continued until 1911. Copper was produced almost continuously from 1915 to 1951. In the 1940's, some disseminated copper mineralization skarns were mined from small open pits located in the Elgin area. Total production from the Helvetia District through 1950 totalled 227 300 tons of ore containing 17 290 000 pounds of copper, 1 097 980 pounds of zinc, and 180 760 ounces of silver (Schrader, 1915; Creasey, 1955).

After 1950, activities consisted mainly of exploration and development drilling. The Lewisohn Copper Company conducted a drilling program in the Peach-Elgin area in 1955 and in 1956 outlined a possible open pit copper deposit in the Peach Hill area (Figure 3). Drilling in 1956 by American Exploration and Mining Co. in the Ingersoll breccia area, located southeast of Broadtop Butte, failed to outline an economic deposit. In the late 1950's the Helvetia Deposit was acquired by the Banner Mining Company, and a modest exploration drilling program was conducted in the area. During this Banner program, drill hole G-33 penetrated the first significant porphyry copper mineralization in the Rosemont area. This hole contained a 300 m intercept of greater than 0.90% Cu mineralization. Anaconda Mining Company acquired the property in 1963 and carried out an extensive mapping and drilling program. The vast majority of the modern information on the Helvetia Deposit was developed by Anaconda and Anamax personnel. Their efforts resulted in the delineation of the Rosemont area porphyry copper deposit, a major North American copper resource. The property was incorporated into the Anamax Mining Co. when Amax joined Anaconda in a partnership in 1973. Anamax sold the property to a real estate company in 1986 which in turn sold it to Asarco in 1988.

Geology

The four Helvetia copper deposits occur within a series of moderate to steeply dipping Paleozoic and Mesozoic sedimentary rocks that have been intruded by Laramide igneous rocks. Mineralization and alteration are primarily contact pyrometasomatic (Creasey, 1955), and hydrothermal alteration and zoning of sulfide

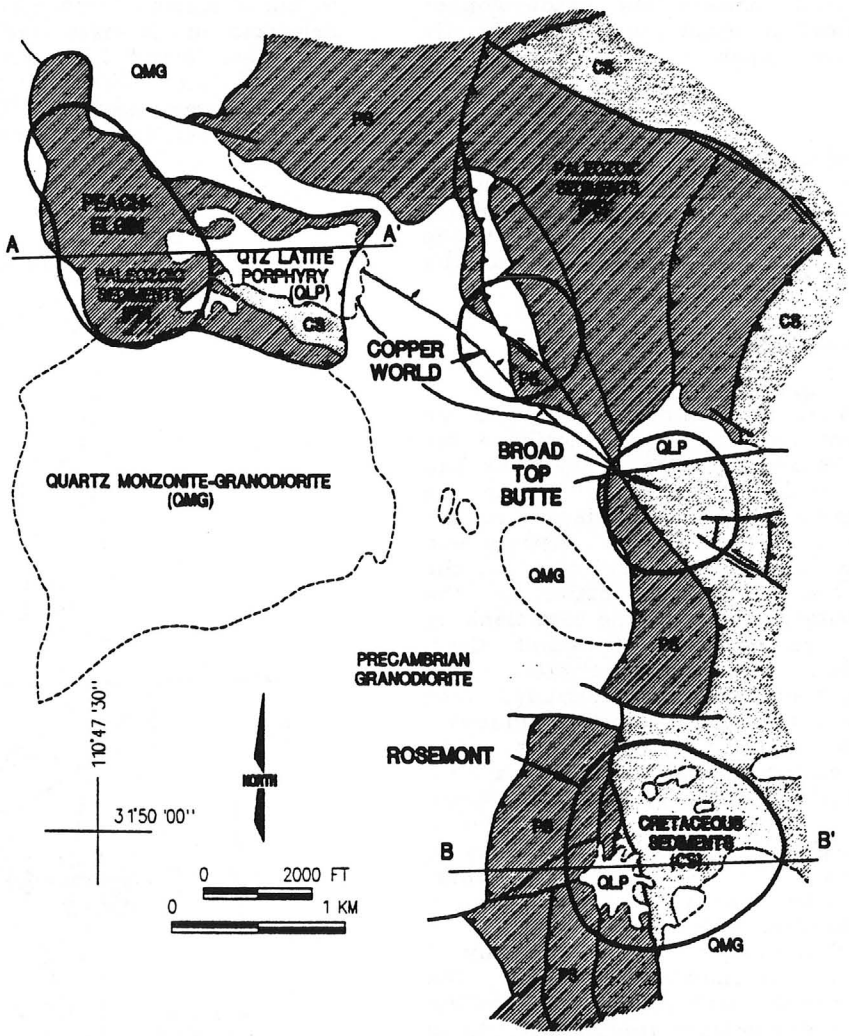


LOCATION MAP - HELVETIA COPPER DEPOSIT

FIGURE 1

mineral assemblages are similar to those found at Asarco's Mission mine and Cyprus Mining Company's Twin Buttes mine. The Paleozoic stratigraphic sequence, ranging from the Cambrian Bolsa quartzite to the Permian Rain Valley Formation, correlates well with the stratigraphic sections developed in the Twin Buttes and Mission mine areas. The Paleozoic rocks are chiefly limestone, dolomitic limestone, and quartzite; the Mesozoic rocks, primarily Cretaceous in age, consist of shales, sandstone, arkose, and impure limestone (Creasey, 1955). The thickness of the Paleozoic stratigraphic section in the deposit area totals approximately 1828 m (Figure 5) (McNew, 1981).

Two types of Paleocene intrusives cut the Paleozoic-Mesozoic strata in the region. One, a granodiorite stock, is found primarily in the western portion of the project area (Figure 2). The other, a moderate to strongly altered quartz latite porphyry, is closely associated with copper mineralization. The quartz latite porphyry is locally mineralized and strong copper mineralization in adjacent skarns is considered to be genetically related to this porphyry. The principal alteration features in the quartz-latite porphyry are sericite and clay alteration of the feldspars, partial destruction of the mafics, and varying degrees of silicification. Limestones in contact with the quartz latite porphyry have locally been metasomatically altered to lime-silicate skarns. McNew (1981) has classified one of the principal components of the skarn as garnet tactite, composed primarily of andradite garnet with varying amounts of quartz, diopside, tremolite, serpentine, wollastonite, and vesuvianite. Endoskarn alteration is occasionally observed in the quartz latite porphyry. Garnet is the predominant endoskarn mineral, vesuvianite is locally abundant, and epidote occurs in small amounts at intrusive contacts (McNew, 1981). Occasional Tertiary lamprophyric dikes penetrate the area and the general region is underlain by Precambrian granodiorite (Figure 2).



GENERAL GEOLOGY OF HELVETIA COPPER DEPOSIT

FIGURE 2 (AFTER H.DREWES & V.J.PERRY)

lization

Sulfide mineralization is considered st-contact pyrometasomatic alteration and curs in all of the altered sediments. While all of the altered sediments are mineralized to some extent, higher grade copper mineralization tends to favor certain skarn horizons indicating that the original rock type and stratigraphy exerted considerable control over ore deposition. Drilling to date in the Rosemont area indicates that the Horquilla and Colina formations were far more receptive to copper mineralization than the other sedimentary formations in the Helvetia Deposit area (Figure 4). Primary sulfide minerals include chalcopyrite, bornite, and pyrite with chalcopyrite and pyrite predominating. Sulfides occur principally as veinlets, coarse disseminations, blebs, and clots within irregular lenticular zones lying in and generally parallel to the lime-silicate areas. Magnetite in varying amounts is found throughout the skarn zone. In the oxidized zone a considerable tonnage of copper occurs as azurite, malachite, cuprite, and chalcanthite. Minor amounts of silver, molybdenite, sphalerite, galena, and scheelite occur throughout the deposit.

The total sulfide content of the deposit is relatively low, seldom exceeding 3% in the altered Paleozoic rocks. The sulfide content of the Mesozoic sequence is somewhat higher due primarily to an increase in pyrite content.

Structure

The structure of the Helvetia copper deposit area is highly complex. The rocks are cut by numerous faults including thrust faults, high-angle normal and reverse faults, and tear faults. Considerable folding of the sediments is observed throughout the area.

A complex assemblage of thrust faults, high-angle normal faults, and tear faults follows the crest line of the Santa Rita Mountains in the Helvetia deposit area. This complex structural zone is known locally as the "Backbone Fault". The Backbone Fault zone forms the western edge of the east dipping block of Paleozoic sediments that include the Rosemont copper deposit. Post-ore faulting, principally high-angle normal and thrust faulting, has had substantial effects on all four mineral areas (McCurry, 1990).

The Peach-Elgin is the most structurally complex of the four copper deposits. It is described in the literature as part of the Helvetia Klippe (Schrader, 1915; Creasey, 1955; Drewes, 1972). The entire Peach-Elgin deposit is underlain by a thrust fault that places Paleozoic and Mesozoic sediments and Laramide quartz-latite porphyry over Precambrian granodiorite (Figure 3). The Helvetia Klippe is considered by some to be the offset upper segment of the Copper World mineral area (Figure 2).

Schrader, 1915; Creasey, 1955; and Drewes, 1972, have described the geology and structural environment of the Helvetia region and the reader is directed to these publications for additional geological information.

Reserves

Approximately 450 drill holes have been drilled throughout the Helvetia Deposit. The Rosemont area has been tested by approximately 130 vertical and angle diamond drill holes. Based on this drilling a computer-generated reserve estimate was completed for the Rosemont copper deposit by Anamax in 1977. This estimate outlined a geological reserve of 362 million tons of sulfide mineralization assaying 0.61% Cu, 0.019% Mo, and 0.25 oz/ton Ag based on a 0.30% copper cutoff. In addition, 66 million tons of copper oxide mineralization assaying 0.53% Cu was estimated. Asarco is continuing to explore and define the Rosemont copper deposit, and there is little doubt that the ultimate copper resource will exceed these preliminary estimates. The waste to ore ratio will depend on the cutoff grade and pit design selected. Using the preliminary Anamax data, the waste to ore ratio is approximately 3:1.

The Peach-Elgin area has been penetrated by 81 churn and diamond drill holes. Based on a 0.40% Cu cutoff, a hand-drawn geological reserve of 23 million tons averaging 0.76% total copper has been delineated. Approximately 60% of this mineralization occurs as sulfides. If a 0.30% Cu cutoff is used, the tonnage doubles and the grade is approximately 0.58% Cu. The waste to ore ratio at Peach-Elgin is less than 3:1.

The current drill hole spacing in the Broadtop Butte and Copper World areas is too wide to accurately define a geological reserve. Opportunities to outline additional mineralization in these target areas appear good.

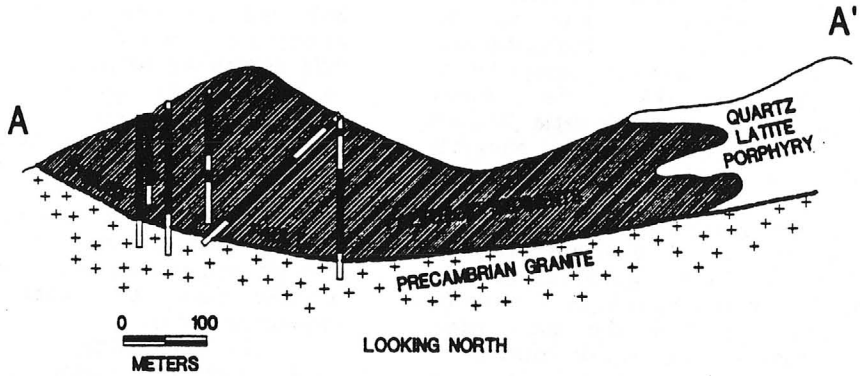
Additional drilling will be required before a minable ore reserve and pit plan can be developed for the entire deposit. Based on current evidence, it appears that the Helvetia deposit contains a geological reserve of copper mineralization in excess of 500 million tons.

Metallurgy

A limited amount of metallurgical testing has been completed on samples from the Rosemont area. This testing indicates that the sulfide mineralization is amenable to concentration by standard flotation methods. These tests produced a copper concentrate assaying 33.5% Cu with payable precious metal credits (Barter, 1987). The sulfide mineralization from the other copper deposits should react to treatment in a similar fashion. A considerable tonnage of oxide copper mineralization is present throughout the deposit. No test work has been completed, but much of the oxide material should be amenable to treatment by SX-EW methods.

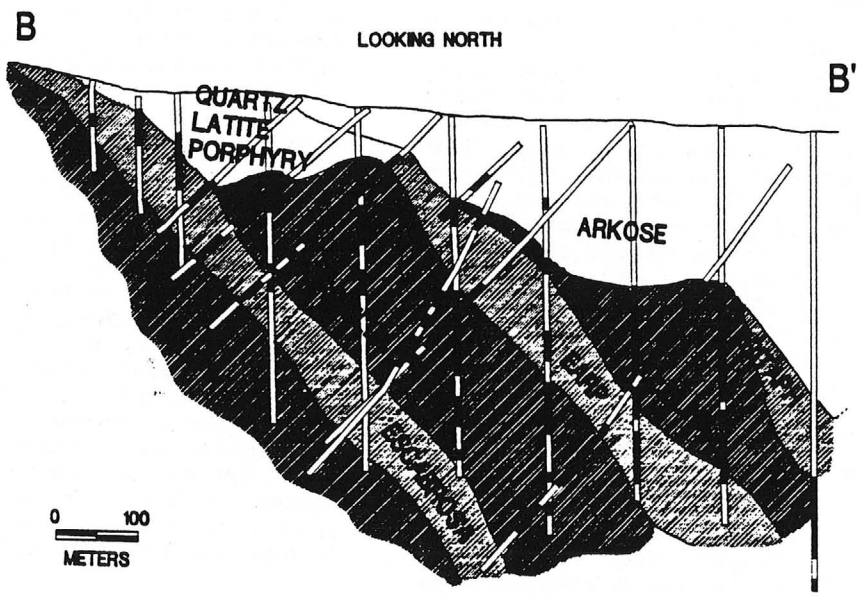
Conclusion

The Helvetia copper deposit ranks as a major skarn type porphyry copper occurrence. It is amenable to open pit mining methods, and metallurgical recoveries should be similar to those achieved at Asarco's Mission Unit. A significant percentage of the copper oxide mineralization present will be amenable to heap



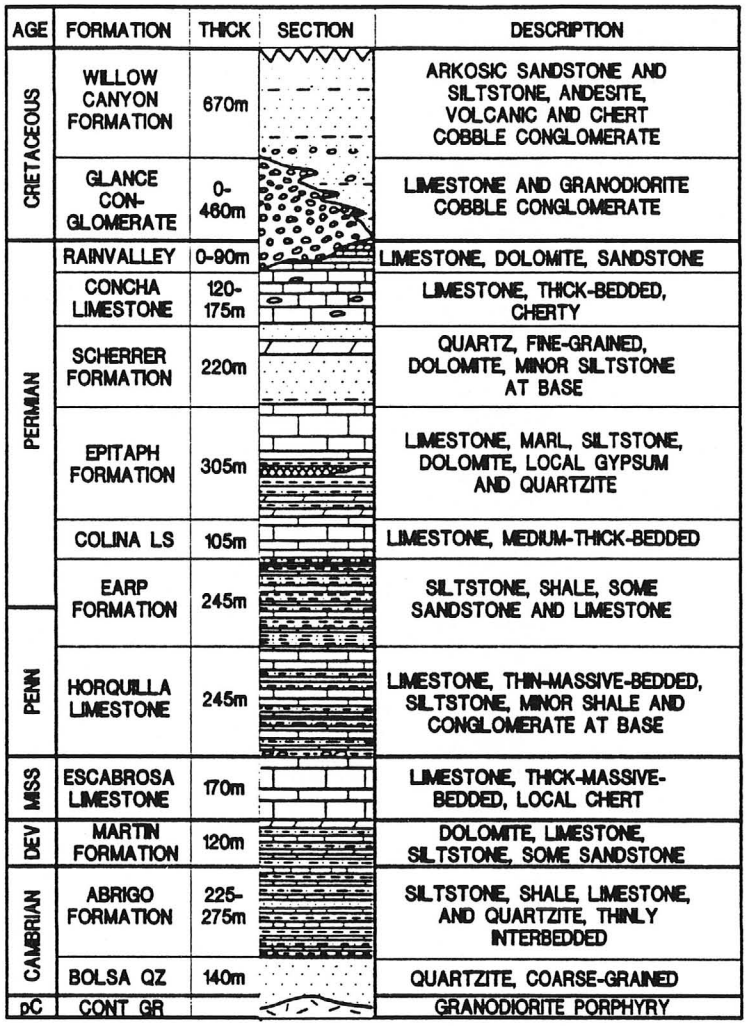
CROSS SECTION THROUGH HELVETIA KLIPPE
SHOWING PEACH-ELGIN AREA +0.3% COPPER INTERCEPTS

FIGURE 3



CROSS SECTION THROUGH ROSEMONT AREA
SHOWING 0.3% COPPER INTERCEPTS

FIGURE 4



STRATIGRAPHIC COLUMN OF THE HELVETIA COPPER DEPOSIT
(AFTER G.E.McNEW, 1981)

FIGURE 5

leaching and SX-EW recovery. Asarco acquired the Helvetia property in 1988 as part of an on-going program to increase its domestic copper reserves. It is continuing development of the property as a resource for the future.

Acknowledgements

The authors wish to express their thanks to ASARCO Incorporated for making possible the presentation of this paper. We also acknowledge the work of F.C. Schrader, S.C. Creasey, G.L. Quick, and H. Drewes of the USGS; V.D. Perry, P.H. Pickard, R.C. Baker, W.J. Garmoe, W.G. McCurry, and C.F. Barter of Anaconda and Anamax; G. Jackson of Banner Mining Co.; and G.E. McNew, whose outstanding geological work formed the basis for this presentation.

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October 21, 1942

Mr. R. A. Burney
Helvetia Mining & Milling Co.
Tucson, Arizona

Dear Mr. Burney:

We note in recent correspondence, relative to your operation, that there is some possibility of your shutting down. If this is the case, have you considered possibility of turning the property over to others who might be willing to operate it?

We have inquiries from several established mining companies relative to their acquisition of new properties, particularly operators previously mining and milling gold ores, who would like to find a base metal property on which to move their equipment and personnel.

If you have any ideas along this line we would be pleased to hear from you and will present your proposal to one or two interested organizations whose operating reputation is beyond question.

Very truly yours,

Earl F. Hastings
Assistant Director
Projects Engineer

EFH:BA

Tucson, Arizona

October 20, 1942

Major General A. M. Tuthill
State Director of Selective Service
3018 Professional Building
Phoenix, Arizona

Dear General Tuthill:

I am enclosing copies of two memorandum reports from George A. Ballam who is field engineer for the Department of Mineral Resources in the southern district.

The action of the Local Board on Selective Service has resulted in the shutting down of the mill operations of the Helvetia Mining & Milling Company and means the cutting off of a monthly production of 100,000 pounds of copper. We sent notices to all mining companies of a bulletin from your office which instructed the Local Boards to reconsider the classification of all key men in the mining industry. From the action indicated in the two memorandum reports it would seem as though proper consideration is not being given to the mining industry. At least not in this particular case.

We are doing our utmost to step up production and this action and the action of the local Florence board does not appear to be in line with the general war efforts.

Mr. Burney, the manager of the Helvetia Mining & Milling Company has on advise from our Department been considering the application for an RFC General Mine Loan to more than double the production of copper from his property. In view of the action and conditions at this property it looks as though we are about to lose the present 100,000 pounds of copper production per month and also an additional potential tonnage of the same amount.

I would appreciate knowing just what action or what assistance we can be in trying to get this situation in line. With best wishes and kindest regards.

Very truly yours,

J. S. Coupal, Director

JSC:ba

October 21, 1942

MEMORANDUM

HELVETIA MINING & MILLING CO.
R. A. BURNEY, MANAGER.

TO:: George Ballam

FROM: J. S. Coupal

I received your two memorandums, one on the Mine Freezing Order and the other on deferment for miners regarding Mr. Burney of the Helvetia Mining Company.

On the deferment question for Mr. Burney I immediately contacted Colonel Laird and submitted copies of your report. Today I discussed the question with Colonel Duffy who had personally investigated Mr. Burney's case. He consulted with the manager of the local board at Florence and was informed that Mr. Burney had been advised that he was in Class 3-A, and that reconsideration of his case would not come before the local board for another 90 days and at that time he would undoubtedly be reclassified as 2-B, which means that he would be definitely deferred from draft.

Colonel Duffy criticized us severely for having reported as we had on the transfer from 3-A to 1-A. I am afraid Mr. Burney misunderstood the instructions from Mr. Fulbright, the local board member of the Selective Service at Florence. The local board are paying strict attention to the orders from headquarters on deferment of miners. It is going to be quite necessary that we check carefully all statements made in such instances as Mr. Burneys and see to it that we get authentic reports on such cases. If we are to do any work toward helping in such instances it may be necessary to 'phone the local board and see that the statements made are correct; otherwise, when we make a kick and we can not substantiate the statements made we are putting ourselves in a position where our complaints will not be heeded.

Regarding the Mine Freezing Order--we know that the freezing directive has backfired in a number of instances. It is a problem to keep labor on the job right now and it is up to the individual manager to do their utmost to keep up production. If the men are soldiering or are not putting in regular hours, it is up to men like Mr. Burney to go to the U. S. Employment Service and try to get men who will stay on the job. I will say that the draft boards are not ignoring the mine deferment requests.

I hope that Mr. Burney can see his way clear to get labor to continue operations and I do feel that he can be assured that his deferment will hold as long as he is producing copper.

DEPARTMENT OF MINERAL RESOURCES

REPORT TO OPA ON ACTIVE MINING PROJECT

Date 6/11/45

Name of Mine Helvetia

Owner or Operator Ramsey Bros

Address 918 E Waverly Tucson

Mine Location Helvetia

Filing Information

File System.....

File No.....

This chart to be used for gallons of gasoline required per month.

PRESENT OPERATIONS: (check X)

Production X; Development.....; Financing.....; Sale of mine.....;

Experimental (sampling).....; Owner's occasional trip.....;

Other (specify).....

PRODUCTION: Past and Future.

	Tons
Approx. tons last 3 months	
Approx. present rate per 3 months	
Anticipated rate next 3 months	
If in distant future check (X) here	

EQUIPMENT OPERATED: Additional gas for hauling

Type	Quantity or Horse Power	Miles or Hours Per Month	Gallons Required Per Month
Personal Cars			
Light or Service Trucks			
Ore Hauling Trucks			3900
Compressors			
Other Mine or Mill Eqpt.			

PRODUCT PRODUCED OR CONTEMPLATED: Name metals or minerals.

✓ Copper

REMARKS:

ARIZONA DEPARTMENT OF MINERAL RESOURCES

By George H. Collins

DEPARTMENT OF MINERAL RESOURCES

REPORT TO OPA ON ACTIVE MINING PROJECT

Date 1/27/43

Name of Mine Helvetia

Owner or Operator Mrs R B Blankenship

Address 298 Granada St, Tucson

Mine Location Helvetia Mng Dist - 35 mi S Tucson

Filing Information

File System

File No.

This chart to be used for gallons of gasoline required per month.

PRESENT OPERATIONS: (check X)

Production ✓; Development ; Financing ; Sale of mine ;

Experimental (sampling) ; Owner's occasional trip ;

Other (specify)

PRODUCTION: Past and Future.

	Tons
Approx. tons last 3 months	
Approx. present rate per 3 months	
Anticipated rate next 3 months	400 tons per mo.
If in distant future check (X) here	

EQUIPMENT OPERATED:

Type	Quantity or Horse Power	Miles or Hours Per Month	Gallons Required Per Month
Personal Cars	41 Stude	2000	
Light or Service Trucks			
Ore Hauling Trucks			
Compressors			
Other Mine or Mill Eqpt.			

PRODUCT PRODUCED OR CONTEMPLATED: Name metals or minerals.

✓ Copper

REMARKS:

This mine which has been a good producer is resuming operations under new management

ARIZONA DEPARTMENT OF MINERAL RESOURCES

By

DEPARTMENT OF MINERAL RESOURCES

REPORT TO OPA ON ACTIVE MINING PROJECT

Date 1/27/45

Name of Mine Helvetia

Owner or Operator Mrs R O Blankenship

Address 798 Granada St

Mine Location Helvetia Mng Dist

Filing Information

File System

File No.

This chart to be used for gallons of gasoline required per month.

PRESENT OPERATIONS: (check X)

Production ✓; Development ; Financing ; Sale of mine ;

Experimental (sampling) ; Owner's occasional trip ;

Other (specify)

PRODUCTION: **Past and Future.** **Tons**

Approx. tons last 3 months	
Approx. present rate per 3 months	
Anticipated rate next 3 months	
If in distant future check (X) here	

EQUIPMENT OPERATED:

Type	Quantity or Horse Power	Miles or Hours Per Month	Gallons Required Per Month
Personal Cars			
Light or Service Trucks			
Ore Hauling Trucks			
Compressors			
Other Mine or Mill Eqpt. Hoist			800

PRODUCT PRODUCED OR CONTEMPLATED: Name metals or minerals.

✓ Copper

REMARKS: Operation being resumed under owners management.

ARIZONA DEPARTMENT OF MINERAL RESOURCES

By George R Chandler

DEPARTMENT OF MINERAL RESOURCES

REPORT TO OPA ON ACTIVE MINING PROJECT

Date 1/27/43

Name of Mine Helvetia

Owner or Operator B. H. Martin

Address 646 E 2nd St Tucson

Mine Location Helvetia Mng Dist 35 mi. South of Tucson

Filing Information

File System .....

File No. .....

This chart to be used for gallons of gasoline required per month.

PRESENT OPERATIONS: (check X)

Production ✓; Development .....; Financing .....; Sale of mine .....;

Experimental (sampling) .....; Owner's occasional trip .....;

Other (specify) .....

PRODUCTION: Past and Future.

	Tons
Approx. tons last 3 months	
Approx. present rate per 3 months	
Anticipated rate next 3 months	400 per mo
If in distant future check (X) here	

EQUIPMENT OPERATED:

Type	Quantity or Horse Power	Miles or Hours Per Month	Gallons Required Per Month
Personal Cars	40 Ford	7000	
Light or Service Trucks			
Ore Hauling Trucks			
Compressors			
Other Mine or Mill Eqpt.			

PRODUCT PRODUCED OR CONTEMPLATED: Name metals or minerals.

✓ Copper

REMARKS:

Supt of operations returned at this property

ARIZONA DEPARTMENT OF MINERAL RESOURCES

By George A Ballam

DEPARTMENT OF MINERAL RESOURCES

REPORT TO OPA ON ACTIVE MINING PROJECT

Date 2/17/45

Name of Mine Helvetia

Owner or Operator Fernando Tellez

Address 170 S 9th Ave Tucson

Mine Location 15 mi east Sahuarita

Filing Information

File System .....

File No. .....

This chart to be used for gallons of gasoline required per month.

PRESENT OPERATIONS: (check X)

Production ✓; Development .....; Financing .....; Sale of mine .....;

Experimental (sampling) .....; Owner's occasional trip .....;

Other (specify) .....

PRODUCTION: Past and Future.

	Tons
Approx. tons last 3 months	
Approx. present rate per 3 months	
Anticipated rate next 3 months	
If in distant future check (X) here	

EQUIPMENT OPERATED:

Type	Quantity or Horse Power	Miles or Hours Per Month	Gallons Required Per Month
Personal Cars	Flee	1800	
Light or Service Trucks			
Ore Hauling Trucks			
Compressors			
Other Mine or Mill Eqpt.			

PRODUCT PRODUCED OR CONTEMPLATED: Name metals or minerals.

✓ Copper

REMARKS:

This man is working at Helvetia mines and is hauling other employees to work

ARIZONA DEPARTMENT OF MINERAL RESOURCES

By Roger A. Ballam

DEPARTMENT OF MINERAL RESOURCES

REPORT TO OPA ON ACTIVE MINING PROJECT

Date 1/30/45

Name of Mine Telephone

Owner or Operator Mrs. A. B. Blankenship

Address 298 N. Bonita Tucson

Mine Location Helvetia

Filing Information

File System .....

File No. .....

This chart to be used for gallons of gasoline required per month.

PRESENT OPERATIONS: (check X)

Production .....; Development .....; Financing .....; Sale of mine .....;

Experimental (sampling) .....; Owner's occasional trip .....;

Other (specify) .....

PRODUCTION: Past and Future.

	Tons
Approx. tons last 3 months	
Approx. present rate per 3 months	
Anticipated rate next 3 months	3000
If in distant future check (X) here	

EQUIPMENT OPERATED:

Type	Quantity or Horse Power	Miles or Hours Per Month	Gallons Required Per ~~Month~~ gtr
Personal Cars			
Light or Service Trucks			
Ore Hauling Trucks			
Compressors	2		
Other Mine or Mill Eqpt.	Horst		2400 gtr

PRODUCT PRODUCED OR CONTEMPLATED: Name metals or minerals.

Copper

REMARKS:

ARIZONA DEPARTMENT OF MINERAL RESOURCES

By Joseph Raddant

DEPARTMENT OF MINERAL RESOURCES

REPORT TO OPA ON ACTIVE MINING PROJECT

Date: 6/30/45

Name of Mine: Helvetia

Owner or Operator: Robert Romero

Address: 508 W D St Tucson

Filing Information

File System: ....

File No. ....

This chart to be used for gallons of gasoline required per month.

Mine Location: Helvetia dist

PRESENT OPERATIONS: (check X)

Production ✓; Development ....; Financing ....; Sale of mine ....;

Experimental (sampling) ....; Owner's occasional trip ....;

Other (specify) ....

PRODUCTION: Past and Future.

	Tons
Approx. tons last 3 months	
Approx. present rate per 3 months	
Anticipated rate next 3 months	
If in distant future check (X) here	

EQUIPMENT OPERATED:

Type	Quantity or Horse Power	Miles or Hours Per Month	Gallons Required Per Month
Personal Cars	1936 Ford	1800	
Light or Service Trucks			
Ore Hauling Trucks			
Compressors			
Other Mine or Mill Eqpt.			

PRODUCT PRODUCED OR CONTEMPLATED: Name metals or minerals.

✓ Copper

REMARKS:

This mine is a heavy producer. Romero employee hauls other employees to work. No quarters available in district

ARIZONA DEPARTMENT OF MINERAL RESOURCES

By [illegible signature]

May 6, 1943

Mr. Charles Taylor
County Assessor
Tucson, Arizona

Dear Mr. Taylor:

Thank you for your telegram which was received in Los Angeles. Please accept my humble apologies for not having replying to it immediately.

I did contact the people I had in mind and who were interested in the Helvetia. They did say that they would not be interested in the low grade milling zinc-lead-silver property you mentioned.

I would like very much to be kept posted on the progress of the Helvetia property and if and when a firm option on reasonable terms can be obtained, I will gladly take it up with these people again.

With best wishes and kindest regards, I am

Very truly yours,

J. S. Coupal, Director

JSC:kk

April 19, 1943

Mr. C. M. Taylor
County Assessor
Pima County
Tucson, Arizona

Dear Mr. Taylor:

While in Los Angeles last week I talked with the party who asked me to make inquiries on the Helvetia property.

I expect to be in Tucson Tuesday afternoon and Wednesday and plan to call and discuss this question with you. I hope that we can get a definite commitment from Mrs. Blankenship even though we do not get a thirty-day option. I believe that after a discussion with you and possibly Mrs. Blankenship, we may be able to advise my parties in Los Angeles by wire and have them on the property within a few days.

With best wishes and kindest personal regards, I am

Very truly yours,

J. S. Coupal, Director

JSC:kk

March 25, 1943

Mr. Charles Taylor
County Assessor
Tucson, Arizona

Dear Mr. Taylor:

While in Tucson yesterday I talked with George Ballam regarding your interest in the Helvetia property owned by Mrs. Blankenship and Messrs. Gregory and Burnie. My understanding is that you have been able to make a reasonable deal with the parties owning this property for taking it over. I do not know whether or not you intend to operate the property personally. I have mentioned the Helvetia and one other property in Arizona to parties whom I consider very responsible and who are anxious to enter into a deal to take over what looks like a promising copper scheelite producing mine.

I have been asked to get all information regarding the property to them and an outline of a deal to take over. If you care to consider this matter, I would be very much pleased to go into further details with you and put you in direct contact with the people I have in mind. It would seem to me as though a contract could be made with them for an overriding clause covering the interest or compensation you expect from turning your contract over to them.

In order to make an equitable deal I do feel as though under the present conditions some people always like to know just what they are paying and to whom the payments go. You may or may not agree with this policy, but it is one that I believe has merit and one that avoids future difficulty in any operations of this nature.

I expect to be in Tucson April 3 to April 5 to prepare for and attend the Scrugham hearing on Monday, April 5. Within a week or ten days after the hearing I expect to make a short visit to the Coast and would like very much to know beforehand whether or not you care to make a tentative deal on the Helvetia so that I may advise my people and go into further detail with you.

I do hope that you can make arrangements to attend the Tucson hearing and be able to present some of the problems which the small mine operators in the State are confronted with and which, if corrected, will lead to a much increased production from the mines.

With best wishes and kindest regards, I am

Very truly yours,

J. S. Coupal, Director

JSC:kk

January 20, 1943

Mr. R. A. Berney
Sahaurita, Arizona

Dear Mr. Berney:

I am making plans to be in Tucson early Saturday afternoon and stay over Sunday and would, if possible, like to meet with you, Mrs. Blankenship, and Mr. Gregory to work out some equitable arrangement for a deal on the Helvetia Mine for you folks and for the Arizona-Eastern Gold Mines Company, the owner of the Octave Mine.

I had hoped that Miss Haskel, the Secretary-Treasurer of the Company, will also be in Tucson at that time.

Can you advise me by phone or otherwise whether or not such a meeting could be arranged, and if so, sometime either late Saturday afternoon or Sunday forenoon would be agreeable and also say just where we could meet.

I would appreciate hearing from you.

I am sending a copy of this letter to Mr. Gregory so that he may try to contact you and get something definite about the possibilities of such a meeting.

With best wishes and kindest regards, I am

Very truly yours,

J. S. Coupal, Director

JSC:kk

cc - Mr. John Gregory
Tucson, Arizona

DEPOSIT SUMMARY REPORT
COPPER

Helvetia East Deposit ROSEMONT
Anamax Mining Company
Pima County, Arizona

by

T. A. Drescher, Geologist
Intermountain Field Operations Center
April 1979

NOTICE

The views and conclusions in this document are the author's and should not be interpreted as necessarily representing the official policies or recommendations of the Interior Department's Bureau of Mines or the U.S. Government. The purpose of this report is to provide information for further review within the Bureau of Mines.

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ABSTRACT - MAS DEPOSIT SUMMARY REPORT

STATE/CNTRY: Arizona/U.S.A. DISTRICT: Rosemont

COUNTY/PSD: Pima COORD:UTM Zone 12;3521700 m north;522,900 m east

QUAD-SCALE: Sahuarita, AZ - 1:62,500 NAME: Helvetia East

COMMODITIES: Copper (Cu), silver (Ag), gold (Au) SEQ. NO.: 0040190010

OWNER/OPERATOR: Anamax Mining Company

TYPE: Proposed open pit mine STATUS: Explored prospect

OPERATION SUMMARY: Proposed open pit mine: 33,069 st (30,000 mt) per day of sulfide ore, 77,162 st (70,000 mt) of waste and oxide ore. Sulfide flotation mill: 33,069 st (30,000 mt)of ore per day producing 555 st (503 mt) per day of 28-percent Cu concentrate containing 4.58 troy ounces per st (157 g/mt) Ag and 0.026 troy ounces per st (0.88 g/mt) Au. Oxide mill to tank-leach 4,106 st (3,725 mt) of ore per day and to produce, after solvent extraction and electro-winning, 18.1 st (16.4 mt) of cathode copper. Concentrate shipped to Magma Copper Company's San Manuel, AZ, smelter and refinery; copper cathodes sold f.o.b. mill.

RESOURCES: 337,000,000 st (305,700,000 mt) sulfide ore containing 0.54 percent Cu, 0.088 troy ounces per st (3.03 g/mt) Ag, and 0.0005 troy ounces per st (0.017 g/mt) Au. 22,000,000 st (19,950,000 mt) oxide ore containing 0.55 percent Cu.

DEPOSIT DESCRIPTION: Porphyry copper deposit in mineralized quartz latite porphyry stock of Tertiary age and in adjacent Paleozoic carbonate sedimentary rocks.

LAND HOLDING: 63,000 acres (25,500 ha) STATUS: Fee ownership, patented and unpatented claims

DOMAIN: Private, national forest AREA POTEN. DISTURB: 5,330 acres (2,160 ha)

ENVIRONMENTAL FACTORS:	Short term:	Long term:
LAND:	Moderate	Minor
WATER:	Moderate	Minor
AIR:	Moderate	Minor
FLORA:	Moderate	Minor
FAUNA:	Moderate	Minor
SOUND:	Minor	Nil
AESTHETICS:	Moderate	Minor
OVERALL:	Moderate	Minor

OPERATIONAL/ECONOMIC DATA: Mine and mills would begin production in 1982 after 3 preproduction years, 3 shifts/day, 357 days/year. Sulfide mill to operate 29 years; oxide mill-15 years. Employees: mine-439 employees; sulfide mill-208; oxide mill-87. Estimated capital: mine-$157,269,700; sulfide mill-$63,359,000; oxide mill-21,012,800. Operating costs: mine, sulfide mill, and oxide mill: $2.638, $1.969, and $5.013/st ($2.908, $2.171, and $5.526/mt) of ore, respectively. Transportation of sulfide concentrate to smelter: $8.173/st ($9.009/mt). Smelter cost: $85.29/st (94.02/mt) of concentrate. Refining cost: $168.97/st (186.26/mt) of blister copper. Breakeven (0.0% ROR) copper price $0.98/lb ($2.15/kg); 15% ROR copper price $1.32/lb (2.91/kg)

	OFFICE LOCATION	DC	CS	IA	E	I	W	A
FILES:	DATA SHEETS					x		
	BACKUP FILES					x		
EVALUATOR:	T. A. Drescher					x		

INTRODUCTION

Helvetia East (figure 1), a porphyry copper deposit located in the Santa Rita mountains near Tucson, Arizona, was discovered by Banner Mining Company in 1961. Other names by which the deposit has been called include Helvetia, East Helvetia, Helvetia-Rosemont, and Rosemont.

The following Minerals Availability System (MAS) deposit evaluation is based upon general information about the regional and district geology and upon an evaluator-proposed mine and mill system. Some preliminary MAS evaluation work in 1978 on the Helvetia East deposit by P. Olmstead was not used as a basis for the present evaluation because more recent and more specific information required a complete re-evaluation. The author acknowledges the assistance of R. A. Salisbury in referring him to some useful sources of information (1, 14) and of R. Baer in providing cost data on an existing electrowinning plant used at another mine. Until recently, almost no specific information about the deposit had been released by Anamax Mining Company, the present owner, but a recently completed environmental study contracted by Anamax (1) gave some basic information needed for an evaluation, including the deposit location, maximum pit limits, mill site, waste dump location, and water requirements for the mill. All costs are estimated in June 1978 dollars.

OPERATION DATA

The following sections summarize information about the deposit location and ownership, past district production, general features, and environmental impact of the proposed operation.

Location and Ownership

The Helvetia East deposit is situated 30 miles [50 kilometers (km)] [1/] southeast of Tucson, Arizona, in the Rosemont mining district of eastern Pima county (figure 2). The Rosemont district is located on the east flank of the northern Santa Rita mountains, across the crest of the range from the Helvetia district. The deposit can be reached from Tucson by driving 21 miles (33 km) southeast on Interstate Highway 10 to the Vail exit, then going south on unimproved State Route 83 for 14 miles (23 km), and, finally, taking an unimproved dirt road southwest for 4 miles (6 km).

The deposit is owned by Anamax Mining Company, an equal partnership between the Anaconda Company (a subsidiary of Atlantic Richfield Corporation) and Amax Arizona Corporation (a subsidiary of Amax Corporation). The corporate address of Anamax is: P.O. Box 127, Sahuarita, AZ 85629, telephone 602/884-7845.

Land Situation

Anamax controls all of the land required for development of the deposit. The area of the proposed open pit is held as Amax-owned patented claims. Adjacent land which would be used for waste dumps, mills, and service shops is presently held by unpatented Anamax mining claims and mill sites in the Coronado National Forest. The area to be used for tailings disposal is held by lease from the State of Arizona. The company is attempting to obtain complete title to a 5,544-acre [2,244-hectare (ha)] block of national forest land (which includes many of Anamax's unpatented claims) through a land exchange with the Forest Service for property owned by Anamax and adjacent to

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1/ Numbers are presented in English units followed by the approximate metric equivalent in parentheses. Values are rounded; therefore, neither is precisely convertible to the other.

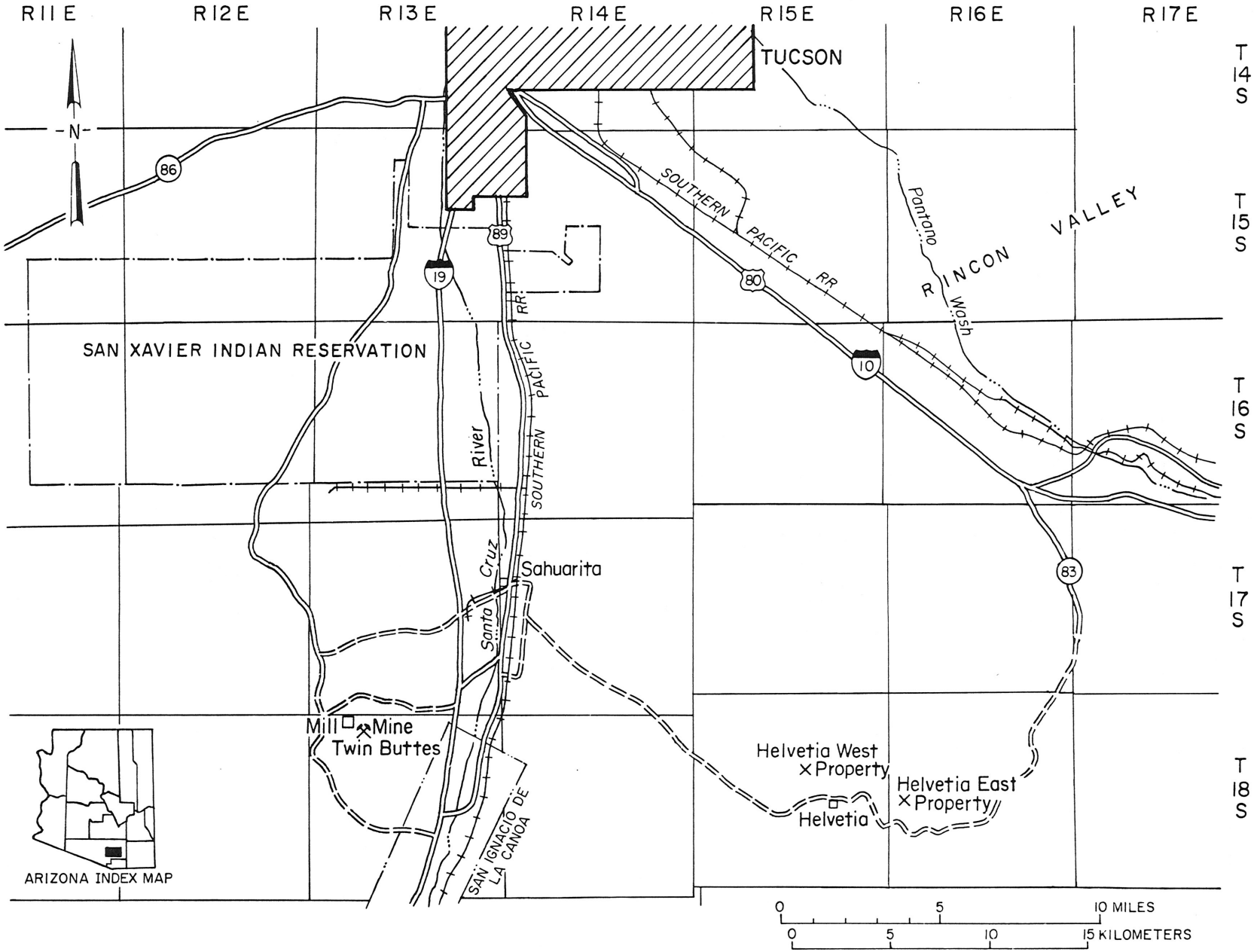

FIGURE 2. - Index map showing location of the Helvetia East deposit.

national forest land in other areas in Arizona (2). In 1974, Anamax purchased the 47,000-acre (19,000-ha) Empire Ranch, a few miles southeast of the deposit, for eventual use as a water source for the proposed mills (1, 13, 21). The total land holdings, after completion of the land exchange, will be approximately 63,000 acres (25,500 ha).

Production Summary

There has not yet been any production from the Helvetia East deposit. Production since the 1880s, from several small mines and prospects overlying the deposit, has totaled about 6,960 short tons [6,310 metric tons (mt)] of ore with an average grade of 7 to 8 percent copper, 1-1/4 troy ounces per short ton [40 grams/mt (g/mt)] silver, and minor gold (15, pp. 123-129). Since initial discovery of mineralization in the 1870s, total production from the Helvetia and Rosemont mining districts has been about 426,000 short tons (386,000 mt) of ore containing an average of 4 percent copper, 0.2 percent zinc, 0.06 percent lead, 0.8 troy ounces per short ton (30 g/mt) silver, and 0.004 troy ounces per short ton (0.1 g/mt) gold (15, p. 31). Since 1959, there has been very little production from the district.

Mine Development, Mining, and Milling Methods

The proposed mining and milling systems are based on a limited amount of general information from an environmental study contracted by Anamax (1). Details of the proposed operation are unavailable and are thus based on a hypothetical system designed in this evaluation. Elecric shovels and truck haulage would be used both during the operation of the proposed open pit mine and during preproduction development to strip overburden and waste from the deposit. The three-year preproduction period would include two

years of stripping. The sulfide ore would be concentrated by standard flotation methods, and the oxide ore would be treated by tank leaching, solvent extraction, and electrowinning.

Operational Integration

The proposed mine and mills would be owned by Anamax. Ore would be trucked 1 mile (2 km) from the mine to the mills. Copper concentrate from the sulfide flotation mill would be trucked 20 miles (32 km) to the rail shipping point at Vail, Arizona, and then shipped 174 miles (280 km) via the Southern Pacific Railroad to Magma Copper Company's Hayden, Arizona, smelter and refinery. Electrowon copper cathodes from the oxide mill would be sold to fabricators f.o.b. the mill.

Environmental Impact of Operation

The results of the environmental study contracted by Anamax (1) indicate that the overall impact of the proposed operation on the environment would be moderate in the short term and minor in the long term. Vegetation would be removed from a 5,330-acre (2,160-ha) area disturbed by the mining operations, resulting in the migration from the area of the wild and domestic animal populations. With the exception of one threatened plant species and three reptile species, whose area of habitat would be reduced, relatively few classified species would be affected (1, p. 62). Removal of vegetation would also result in increased erosion.

Groundwater level in the vicinity of the proposed mine would be lowered by the hydrologic sink created by the open pit, but, within a few years after termination of mining operations, the water table would be restored to its original level by normal annual recharge. As proposed in this evaluation, the water requirements for the mills would be satisfied by sustained pumping

from widely spaced wells on the Empire Ranch, located a few miles south of the operation. The water table should not be appreciably lowered because of the large area over which pumping would occur. Water runoff from the area would be decreased by water impoundment in the pit and on the waste dumps.

Ground cover removal could be expected to create dust problems downwind from the mining area. The scenic beauty of the area would be marred to some extent by the highly visible waste dumps, tailings pond, and open pit. Several sites of archeological and historical interest which might be destroyed by the mining operations will be excluded from the Anamax-Forest Service land exchange and will be held by the Forest Service to ensure their protection (21). Because of the proximity of the deposit to a metropolitan area, local attitudes toward the proposed operation can be expected to be less favorable than for similar deposits in more remote areas; however, since the Tucson area is a major center for copper production, this type of adverse reaction would be somewhat mitigated. The deposit is located about three miles (five km) northwest of a proposed land development for a new residential district (18, p. 4).

CHARACTER OF DEPOSIT

Sedimentary and igneous rocks, complexly folded and faulted and with a considerable range of age and lithologies, occur in the Santa Rita Mountains. The area's oldest exposed lithologic unit, the Precambrian Pinal Schist, occurs in small, isolated roof pendants and fault slivers in the Continental Granodiorite, a regionally extensive Precambrian batholith (11, plate 4; 10, p. 5). A 6,000-foot (1,800-m) thickness of Paleozoic marine sediments unconformably overlies these Precambrian units (10, p. 5). Near the middle of the Permian Period, the region was up-

lifted and subsequent deposition was predominantly continental. Deposition of Triassic and Jurassic redbeds and tuffaceous sediments was preceded and followed by periods of strong regional uplift and normal faulting, after which the Early to Late Cretaceous Bisbee Group of conglomerates, arkoses, and siltstones was deposited (12, p. 315).

The Laramide Orogeny was characterized in the Santa Rita Mountains by 1) a strong early phase of thrust faulting, folding, and plutonism during the Late Cretaceous, 2) a mid-orogenic tectonic lull, and 3) weaker orogenic phases of faulting and intrusion during the Paleocene (11, pp. 29-34). Deposition of thick accumulations of sediments in local basins and volcanic activity were associated with the early phase of the orogeny (12, p. 315). The final phase of the Laramide included the emplacement of the Greaterville intrusives, also called the "ore porphyries" because of their genetic relationship to mineralization in the districts, including the Helvetia East deposit (9, pp. 15, 43-45). Drewes 9, p. 15) believes that the Greaterville intrusives were "probably emplaced at shallow depths from fairly fluid magmas, as indicated by their fine grain size and habit of intruding faults." Mineralization in the districts is associated with argillic-pyritic hydrothermal alteration and intense contact metamorphism (9, p 9), and carbonate rocks in the lower Paleozoic Abrigo and Martin Formations are common host rocks (11, p. 32).

Normal faulting and associated andesitic and rhyolitic volcanism which followed the Laramide are responsible for the present topography of uplifted ranges and adjacent alluvium-filled valleys. Examples of range-front faults in the vicinity of the Helvetia East deposit are the Deering Springs and Backbone faults.

General Description

No specific information has been published on the geology of the Helvetia East deposit. However, general information on the geology of the district is available in a number of recent publications (1, 8, 9, 10, 11, 12, 15). A recent environmental study contracted by Anamax (1) revealed the specific location of the proposed open pit and made it possible to glean much about the geology of the deposit. Two fairly detailed geologic maps of the deposit area have been recently published (1, fig. D-2; and 11, plate 4), and figure 3 is a synthesis of information from both sources. Where differences of opinion on the geology exist, the Anamax map (1, fig. D-2) was given more credence, since the company has the benefit of data from their extensive drilling in the area.

In the environmental study, the company also revealed that some of the drill holes over the deposit penetrated Paleozoic rocks (1, vol. 1, p. 32), indicating that several thousand feet of overlying Mesozoic sediments are faulted out, presumably by Drewes' thrust fault IV (11, p. 20 and plate 4). This low-angle, eastward-dipping thrust typically separates Paleozoic from Cretaceous rocks both to the north and south of the deposit. However, in the immediate area of the deposit, the fault is not exposed because of down-faulting along the Deering Springs and Backbone range-front faults shown in figure 3. In this evaluation, the thrust fault is assumed 1) to be barely hidden below the surface at the intersection of the Deering Springs and Backbone faults, 2) to underlie the Bisbee Group (Glance conglomerate), and 3) to dip ten degrees eastward as it does in surface exposures exposures one mile (two km) to the south (figure 3)(11, p. 20). This assumed location of the thrust fault

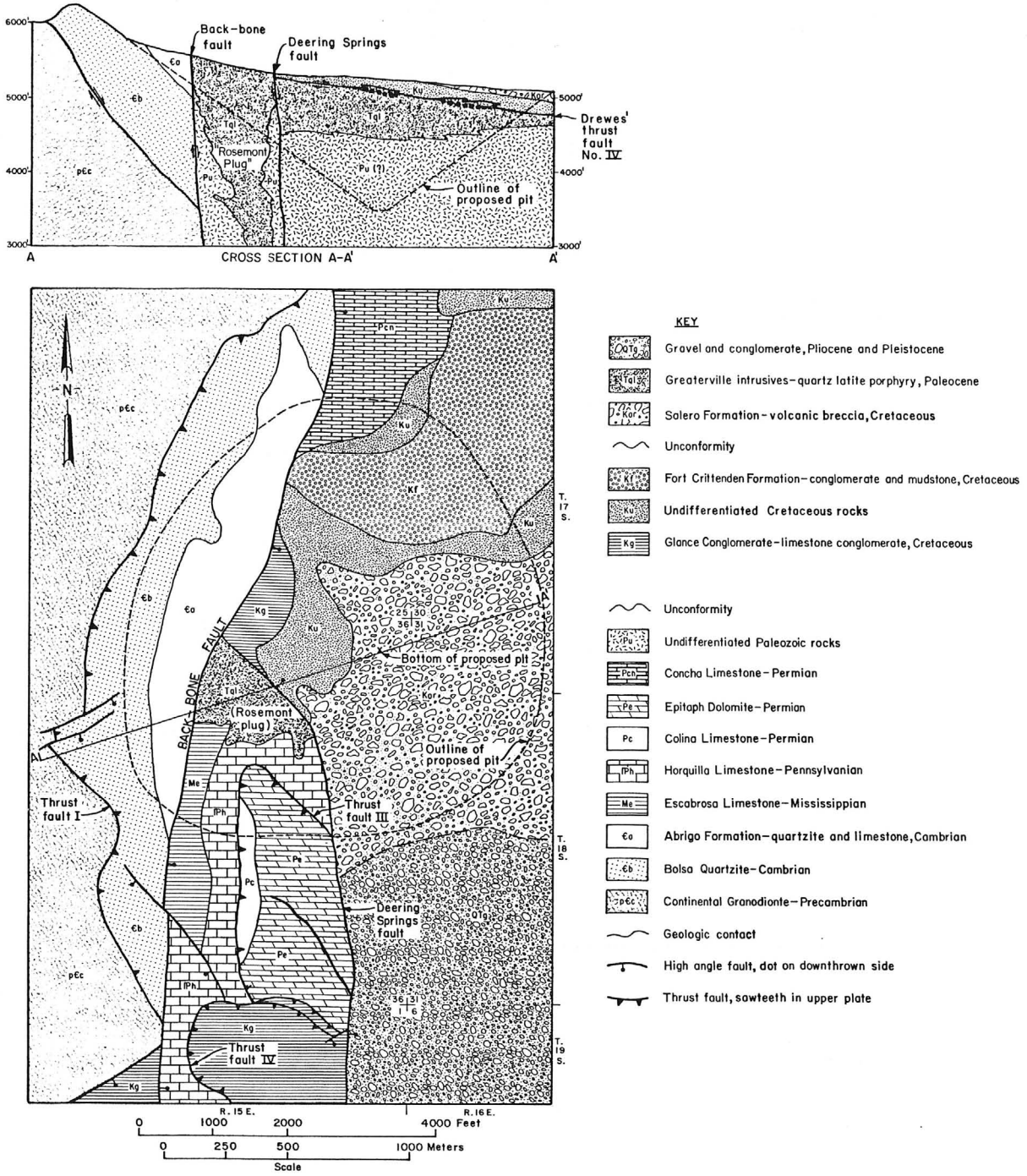

FIGURE 3. - Geology of the Helvetia East deposit (after 1, fig. D2; 11, plate 4).

would require that only a few hundred feet of vertical displacement occurred on the Deering Springs fault, as Drewes implies (11, pp. 1, 19, and 26).

Exposed within the area of the proposed open pit is the Rosemont plug, a mineralized quartz latite porphyry plug belonging to the group of "ore porphyry" intrusives previously described. The portion of the intrusive which is downdropped by the Deering Springs fault (figure 3) is assumed to have invaded the thrust, as is characteristic of the "ore porphyries" (9, p. 15), and thus to be of much wider subsurface extent in the downdropped block than in the upthrown block. Supporting this conclusion is the fact that the Cretaceous rocks exposed at the surface in the downdropped block are 1) strongly argillized and iron-stained, 2) contain anomalous amounts of zinc, lead, bismuth, silver, arsenic, and antimony, and 3) are invaded by small dikes of quartz latite porphyry (9, pp. 44-45).

The ore body has been termed a "porphyry" copper deposit (15, pp. 30-31; 25, p. 47), and it is assumed in this evaluation, for lack of information to the contrary, that the major portion of the deposit occurs within the Rosemont plug. Drewes, however, believes that the geochemical anomalies to the northeast of the plug could indicate mineralization in the Paleozoic carbonate rocks beneath the exposed Mesozoic rocks (9, pp. 44-45), and it is assumed in this evaluation that a lesser part of the ore body consists of contact metasomatic, replacement, and disseminated sulfide deposits of copper and other metals along faults and favorable beds in the Paleozoic rocks beneath the thrust fault (figure 3).

Dimensional Data

A depth of about 200 to 300 feet (60 to 90 m) to the thrust fault (and to the top of the ore body in this interpretation) is not contradicted

by company statements that the ore body is "several hundred feet down" (18, p. 3). Tonnage and volume calculations, assuming an average specific gravity of 2.6 for ore and waste, and average pit slopes of at least 37 degrees from the horizontal, indicate that more than enough room (at least 60 percent more than necessary) exists for the ore body to fit below the thrust fault within the open pit limits (figure 3). If the upper limit to the ore body is the thrust fault and the lateral and lower limits are the maximum pit boundaries, then the ore body must be roughly disk-shaped, dipping ten degrees to the east, having an average thickness of about 600 feet (200 m) and a diameter of 3,000 feet (900 m), and probably thinning considerably to the east (figure 3). In detail, the shape of the ore body may be very irregular, with dikes of porphyry intruding the surrounding rocks along faults and fractures (9, p. 14) and with pyrometasomatic, replacement, and disseminated copper sulfide deposits extending away from the porphyry contact along faults and favorable carbonate beds (15, pp. 123-128; 11, p. 32).

Major Ore and Gangue Minerals

In barren, relatively unaltered surface exposures, the Rosemont plug and other plugs of the "ore porphyry" group in the Santa Rita Mountains consist of closely fractured quartz latite porphyry with saccharoidal groundmass and abundant bipyramidal quartz phenocrysts, sparse small biotite phenocrysts, and traces of disseminated sulfides (16, p. B4). The copper content in unaltered porphyry is two to five times higher than in older intrusives in the district and five to fifteen times higher in biotite concentrates (16, pp. 3 and 5), suggesting that copper is a primary constituent in the porphyry and that copper-rich biotite may be the metal source for the copper deposits in the area.

For lack of specific information released by the company, the ore mineralogy can only be guesstimated from descriptions of oxidized ore mined in surface exposures above the ore body or from typical descriptions of ore from other porphyry copper deposits (22). The "sulfide" portion of the ore body might consist of disseminated to massive sulfide mineralization in argillized porphyry host rock and in adjacent silicated carbonate rocks. Sulfide minerals probably include pyrite, chalcopyrite, and bornite, with possibly some chalcocite supergene enrichment. The "oxide" portion might consist of oxidized products of the sulfide minerals, such as chrysocolla, azurite, malachite, and cuprite.

EXPLORATION LEADING TO DISCVOERY

Operating intermittently from the late 1800's through the 1950's, several small mines within the periphery of the proposed Helvetia East pit have produced high-grade copper ore from pyrometosomatic deposits at or near the contact of the Rosemont plug with Paleozoic carbonate rocks (15, pp. 123-128). For an extended period from 1948 through 1961, Banner Mining Company gradually acquired several properties in the Helvetia area (18, p. 3, 5, pp. 47-48). Diamond drilling by Banner from 1961 to 1963 resulted in the discovery of mineralization on two of the properties, called in this evaluation the Helvetia East and Helvetia West (3, p. 53). In March 1963, Banner leased the properties to the Anaconda Company. Anaconda continued the exploration drilling program and more definitively determined the shape, tonnage, and grade of the Helvetia East deposit (3, p. 53). In 1973, concomitant with formation of Anamax Mining Company (an Arizona partnership between Amax and Anaconda mining companies), Banner Mining Company was merged into the new partnership. Since 1973,

Anamax has shown continued interest in the deposit through additional geologic and economic evaluation of the deposit (3, p. 15), acquisition of lands adjacent to the deposit, and environmental studies (1).

RESERVE ESTIMATION

The sulfide and oxide portions of the Helvetia East reserves are entered respectively in quantity-resources matrices one and two of the Minerals Availability System (MAS) data base (see appendix A) from recently published data (27, p. 67). As the detailed geological relationships of the ore body are unknown, no attempt was made to subdivide the reserves by probability of occurrence, and the quantity of reserves entered at the 90-percent probability level in quantity-resource matrices one and two is repeated at lower probability levels. Because of a large tonnage difference from previous, more reliable estimates (3, p. 54; 27, p. 67), a published reserve estimate (26, p. 110) of slightly more recent date (reserve record 5 in appendix A) was not used as a basis for the quantity resource matrices. The sulfide reserves are 337,000,000 short tons (305,700,000 mt) of ore containing 0.54 percent copper, 0.088 troy ounces per short ton (3.03 g/mt) silver, and 0.0005 troy ounces per short ton (0.017 g/mt) gold. The oxide reserves are 22,000,000 short tons (19,950,000 mt) of ore containing 0.55 percent copper. Because gold and silver grades have not been published, they were estimated from average gold to copper and gold to silver ratios in past production from mines above the deposit and from the Helvetia and Rosemont districts (15, pp. 31, 123-129).

Under the development plan proposed in this evaluation, the sulfide ore will be mined over a period of 29 years at a production rate of 33,069 short tons (30,000 mt) per day, 357 days per year, and the oxide ore will

be mined over a 15-year period at a 4,106-short-ton (3,725-mt) per day, 357-day-per-year rate.

EXTRACTION TECHNOLOGY

As very little information has been released by Anamax on methods of mining and milling, it was necessary to propose an extraction system. The meager information on which assumptions are based was published in an Anamax environmental study (1) giving 1) mine pit and waste dump location and maximum areal extent, 2) mill location and water consumption, 3) concentrate haulage route and rail shipping point, 4) water table depth and typical water well yields, 5) date of earliest possible production, and 6) rough employment estimates during both production and preproduction development.

Mining and milling systems were designed using the above information in combination with models described in a Bureau of Mines cost-estimating handbook (24). An oxide tank-leaching and electrowinning mill was designed using the knowledge that Anamax actually employs this system to treat its oxide ore at the nearby Twin Buttes mine.

Proposed in this evaluation is a water supply system from numerous, widely spaced water wells which could be installed on the extensive, 47,000 acre (19,000-ha), Anamax-owned Empire Ranch. This method, although expensive compared with other methods, was chosen for this evaluation because of the reliability of obtaining a constant, uninterrupted (by drought) water supply and because of the minimal lowering of the water table (and consequent environmental damage). The Empire Ranch was purchased by Anamax as a water source for the Helvetia East project in 1974 for $12,808,000 (21; 23, p. 16; 13).

Figure 4 shows the general layout of the mining operation, including the water supply and tailings disposal system.

Mining System

The proposed open pit mine would operate three shifts per day, 357 days per year, and employ 439 personnel. By projecting 37-degree pit slopes from the maximum pit perimeter, shown superimposed on a topographic map in the environmental study (1), the maximum depth and elevation contours of the pit were calculated. By the same method, a total ore plus waste tonnage of 1.205 billion short tons (1.093 billion mt) was estimated, assuming an average ore and waste specific gravity of 2.6. Knowing this total tonnage and the total ore tonnage, one can calculate an overall stripping ratio of 2.575 to one (waste to sulfide ore). Assuming a constant sulfide ore production rate of 33,069 short tons (30,000 mt) per day, and assuming a two-year period of preproduction stripping of waste and overburden at the operating rate of materials handling, an operating stripping ratio of 2.33 to one (waste to sulfide ore) can be calculated. The waste mining rate would thus be 77,162 short tons (70,000 mt) per day during the 29-year production life of the mine, and a total of 110,231 short tons (100,000 mt) per day of material would be removed throughout the 31-year preproduction (stripping) plus production life of the mine. During the two-year preproduction stripping period, 78,700,000 short tons (71,400,000 mt), or 35,900,000 cubic yards [27,500,000 cubic meters (cu m)], of overburden and waste would be stripped from the deposit. Included in the waste tonnage during the first 15 years of production is the oxide ore production of 4,106 short tons (3,725 mt) per day. The maximum pit depth at the end of the mine

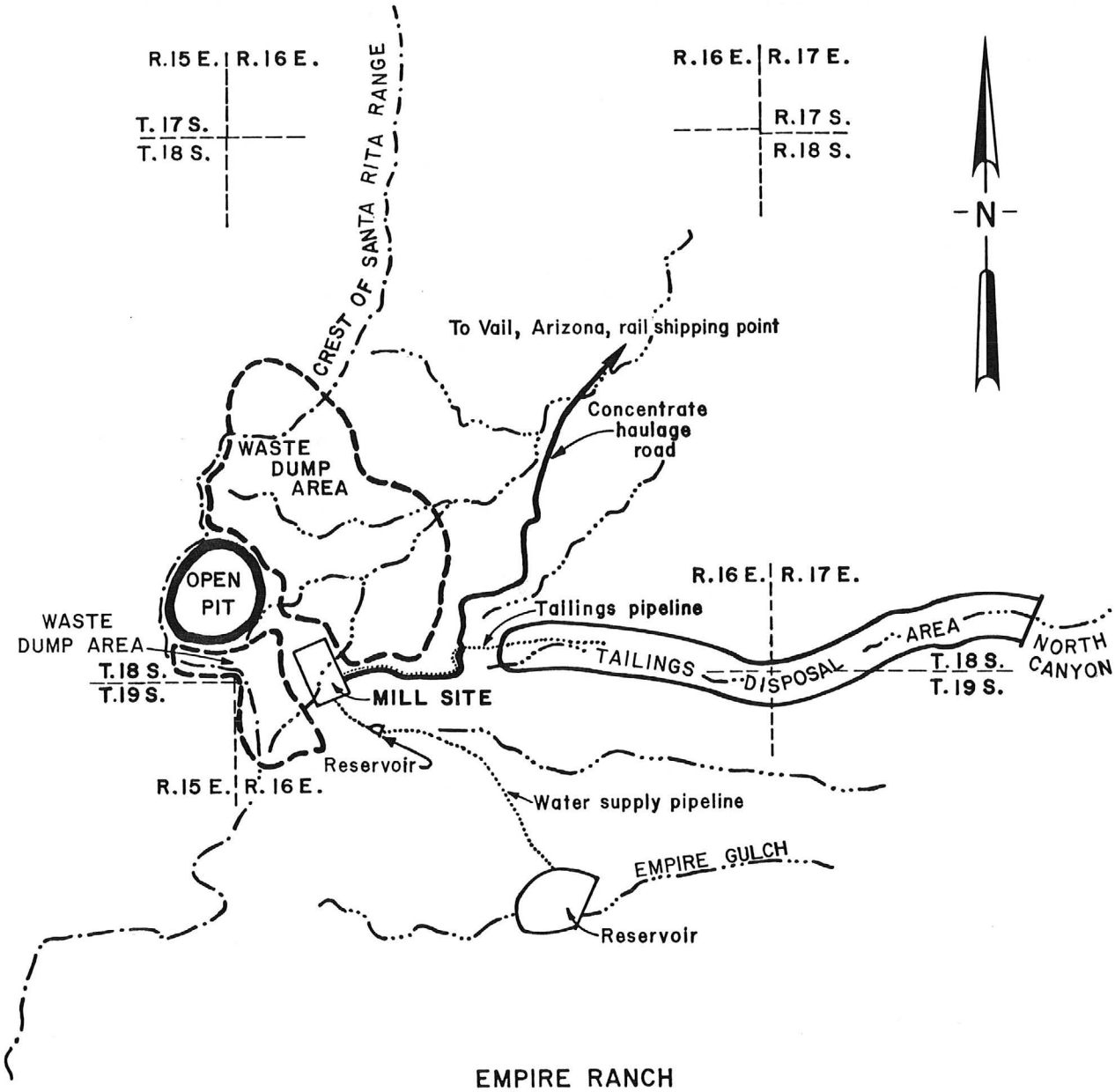

FIGURE 4. - General layout of the proposed mining, milling, and water supply system.

life would be 1,600 feet (490 m), measured from the lowest point on the pit rim, and 2,600 feet (790 m), measured from the highest point on the rim.

Equipment proposed for the operation is listed in table 1. Actual production time per eight-hour shift for all equipment is assumed to be seven hours (87.5 percent utilization). Rotary drills would drill 55-foot (17-m) deep, 12-1/4-inch [31-centimeter (cm)] diameter holes with 30-foot (9-m) spacing and 27-foot (8-m) burden. A 70-percent equipment availability for drills is assumed. Benches of 50-foot (15-m) height would be blasted after loading the holes with ammonium nitrate-fuel oil (AN/FO) blasting agent. The broken ore or waste would be loaded into 85-short ton (77-mt) reardump trucks by ten-cubic yard (7.6-cu m) electric shovels and front-end loaders. An average swell factor for all mined material of 61 percent is assumed. The trucks would haul ore or waste an average distance of one mile (1.6 km) up an eight-percent grade to the rim of the pit, then either 0.7 miles (1.1 km) on a slight downgrade to the mills or 1.5 miles (2.4 km), on the average, over a level grade to the waste dumps. The trucks would have a cycle time of 14 to 18 minutes, depending on loading method and destination (6, pp. 16-6 to 16-9; 19, pp. 571-577). An 85-percent equipment availability for the trucks is assumed (19, p. 579). Service and road maintenance equipment includes bulldozers, graders, pick-up trucks, and miscellaneous mechanical and electrical vehicles. Exploration drilling within the pit during mining would be done by an NX core drill.

TABLE 1. - Mine equipment

Equipment description	Number of pieces
Trucks, Caterpillar 777, 85-ton	17
Shovels, 10-cubic yard	4
Front-end loader, Caterpillar 992B, 10-cubic yard	1
Rotary drills, 12-1/4 - inch diameter holes	3
Core drill, NX	1
Bulldozers	5
Graders	2
Pickup trucks	7
Mechanical and electrical vehicles	7

An employment breakdown based on labor factors from a Bureau of Mines cost estimating handbook (24) is given in table 2, and table 3 lists productivities for the mine.

TABLE 2. - Mine employment

Labor category [1]	No. of employees [2]
Direct	
Excavation, load and haul	
Ore	52
Overburden and waste	119
Drill and blast	
Ore	7
Overburden and waste	16
Maintenance [3]	97
Total direct	291
Indirect	
General operations	40
Administrative [4]	
Supervisory	39
Technical	50
Clerical	19
Total indirect	148
Total employment	439

1/ Labor categories (except maintenance) from Bureau of Mines cost-estimating handbook (24).

2/ Number of employees calculated from labor portions of operating costs which were estimated from Bureau of Mines cost estimating handbook (24).

3/ One-third of the direct labor has been assigned as maintenance labor, as was done for a similar-sized mine (4, p. 73).

4/ Administrative labor breakdown based on a breakdown in the Bureau of Mines handbook (24, p. 44).

TABLE 3. - Mine productivity 1/

Labor category	Productivity, mt per employee per man-shift
Direct	116
Indirect	228
Overall	77

1/ Productivities are given in total ore tonnage (i.e., sulfide and oxide ore) produced per employee.

Beneficiation System

Depending on the degree of oxidation of contained copper minerals, ore would be processed either in the 4,106-short-ton (3,725-mt)-per-day-capacity oxide, tank leaching and electrowinning mill or in the 33,069-short-ton (30,000-mt)-per-day-capacity sulfide flotation mill. Both mills would operate three shifts per day, 357 days per year. The sulfide mill, employing 208 personnel, would operate throughout the life of the mine, and the oxide mill, employing 87 personnel, would operate only during the first 15 years of mine life, after which the oxide ore reserves will have been extracted. Tables 4 and 5 give breakdowns of employment and productivity for the sulfide and oxide mills, respectively.

Water to supply the mills, estimated at 19,000 acre-feet per year, or 12,000 gallons per minute (gpm) 66,000 cu m/day) (1, v. II, p. iv.), would be supplied by a system of 120 water wells, drilled at 4,100-foot (1,250-m) spacings on the Empire Ranch. Each well would consist of a 5-inch (13-cm) hole, rotary drilled in alluvium to an average depth of 150 feet (46 m), lined with perforated steel or aluminum casing, and equipped with a 100-gallon-per-minute (six-liter/second) submersible pump, plastic pipe, and a small surface storage tank. Water from the well storage tanks would flow by gravity through a system of plastic and cement pipe (with increasing diameter at junctions) to a storage reservoir in Empire Gulch (section

TABLE 4. - Employment in mills

Labor category [1]	Number of employees [2]	
	Sulfide mill	Oxide mill
Direct		
Crushing	16	7
Grinding	11	7
Regrinding	7	-
Leaching and solvent extraction	-	8
Electrowinning	-	24
Flotation	14	-
Concentrate thickening	1	-
Concentrate filtering	2	-
Tailings dewatering	2	1
Transport and place tailings	7	3
Maintenance [3]	39	14
Total direct	99	64
Indirect		
General operations	45	11
Administrative [4]		
Supervisory	18	4
Technical	28	5
Clerical	18	3
Total indirect	109	23
Total employment	208	87

1/ Labor categories (except maintenance) from Bureau of Mines cost-estimating handbook (24).

2/ Number of employees calculated from labor portions of operating costs which were estimated from Bureau of Mines cost-estimating handbook (24).

3/ A portion of the direct labor has been assigned as maintenance labor, as was done for similar mills (4, pp. 118, 120, and 136).

4/ Administrative labor breakdowns based on a breakdown in the Bureau of Mines handbook (24, p. 246).

TABLE 5. - Productivity in mills

Labor category	Productivity, mt per employee per man-shift	
	Sulfide mill [1]	Oxide mill [2]
Direct	303	58
Indirect	275	162
Overall	144	43

1/ Productivity in mt of sulfide ore processed per employee.

2/ Productivity in mt of oxide ore processed per employee.

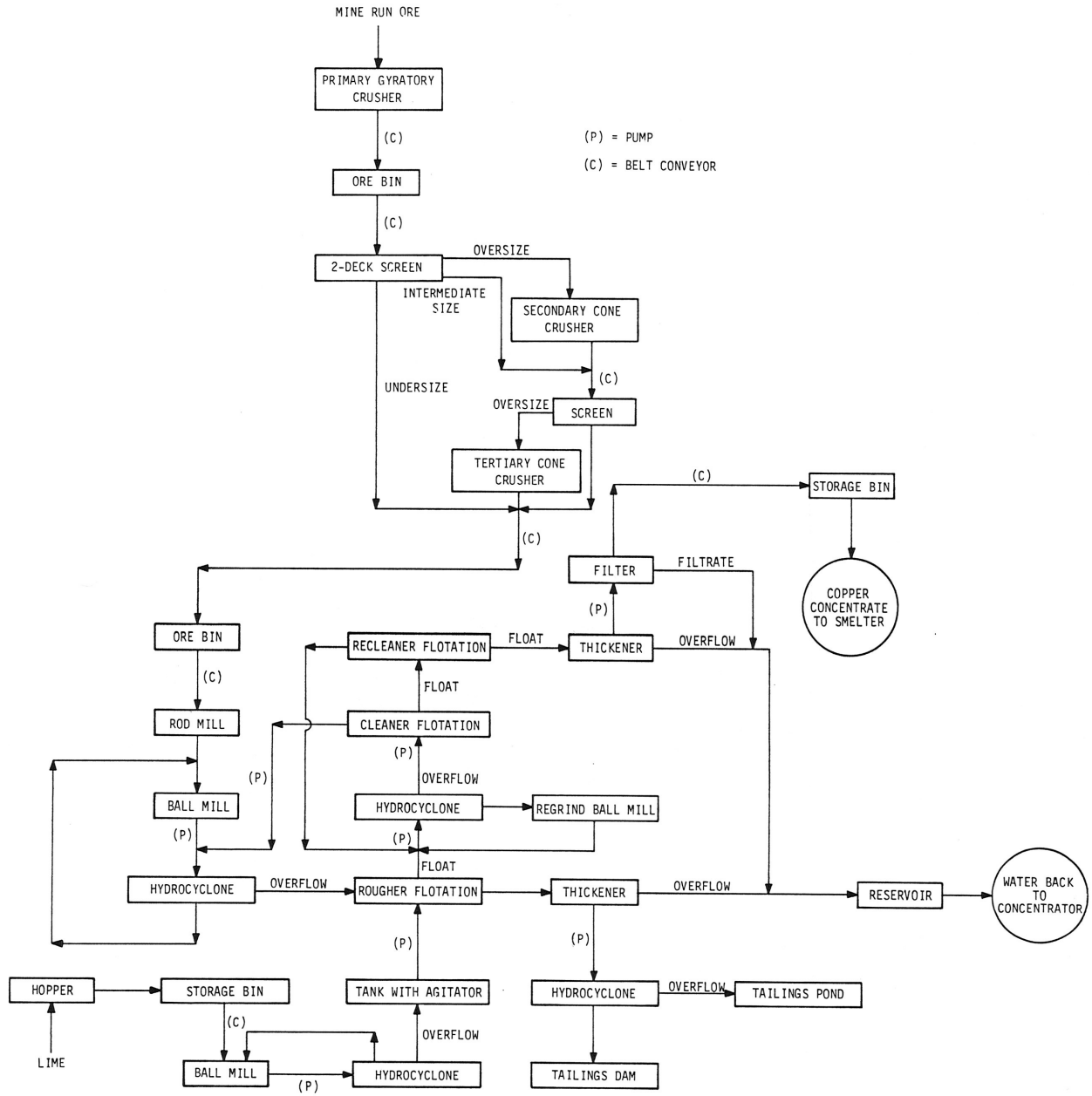

FIGURE 5. - Flow sheet of the proposed sulfide flotation mill (after 4).

15, T. 19 S, R. 16 E). The reservoir, contained by an earthfill dam and designed to hold a two month's supply of mill water, would be held at low water levels to minimize evaporation loss and to permit the catchment of runoff from infrequent summer storms. From the reservoir 12,000 gpm (66,000 cu m/day) of water would be pumped through a steel flume to a smaller reservoir (one day capacity) located above the mills. The sulfide mill would use about 10,500 gpm (57,200 cu m/day) and the oxide mill about 1,500 gpm (8,200 cu m/day). Water from the tailings pond would not be reclaimed because of the long [8-mile (13-km)] distance to the tailings pond in North Gulch.

The mills are described separately in the following sections.

Sulfide Mill

The following description of the beneficiation process is based on published descriptions of typical copper flotation mills (4, pp. 98-114; 24, pp. 195-298). Figure 5 is a flow sheet of the mill. Ore would be reduced in size to 80-percent minus 3/8-inch (0.95-cm) in a primary gyratory crusher and in secondary and tertiary cone crushers, ground to minus 100-mesh in rod and ball mills, and floated in rougher, cleaner, and recleaner cells. Approximately 10 percent of the original mill feed would be reground following rougher flotation. Concentrate would be thickened, filtered, dried, and stored before shipment to the smelter. Tailings would be partially dewatered in thickeners at the mill and then pumped to the disposal pond as described in the preceding section. Table 6 gives an equipment list for the mill. Concentrate would be trucked 20 miles (32 km) north to the Vail, Arizona, railroad shipping point, then shipped 174 miles (280 km) to the Hayden smelter and refinery.

TABLE 6. - Equipment for sulfide flotation mill

Equipment description	No. of pieces
Gyratory (primary) crusher, Nordberg 54-80 H.D.	1
Gyratory (primary) crusher, Allis Chalmers 30-70	1
Cone (secondary) crusher, 7-ft Symons standard	3
Cone (tertiary) crusher, 7-ft Symons shorthead	4
Rod mill, Allis Chalmers 14 x 18-ft.	6
Ball mill, Allis Chalmers 14.5 x 28-ft.	6
Flotation cell, Galigher 120 Agitair	216
Ball mill (regrind), 7.5 x 23 ft.	6
Vibrating screens	2
Conveyor belts	10
Storage bin, fine ore	2
Cyclones	25
Pumps	30

Oxide Mill

The following description of the oxide mill follows closely (with minor modifications) the published descriptions of Anamax's Twin Buttes leaching, solvent extraction, and electrowinning mill (20, pp. 44-45, 14). After crushing to 80-percent minus 3/8-inch (0.95 cm), as in the sulfide mill, the ore would be wet ground to minus 65 mesh in rod and ball mills while maintaining a pulp density of 72-percent solids. At the ball mill discharge, water would be added to provide a 60-percent solids slurry feed to the leaching tanks.

Approximately nine-tenths of the ground ore slurry would go directly to the leaching tanks, the remainder to the pH adjustment tanks to raise pH (figure 6). The actual split would depend on the lime content of the ore and on the pH of the pregnant solution from the leaching tanks. Sulfuric acid, to be obtained cheaply from any of several nearby smelters, would be added to the ground ore slurry at the first in a series of five mechanically-agitated leach tanks. Acid consumption, assuming a similar lime content to the Twin Buttes oxide ore, may be as high as one weight unit of acid for every eight weight units of ore.

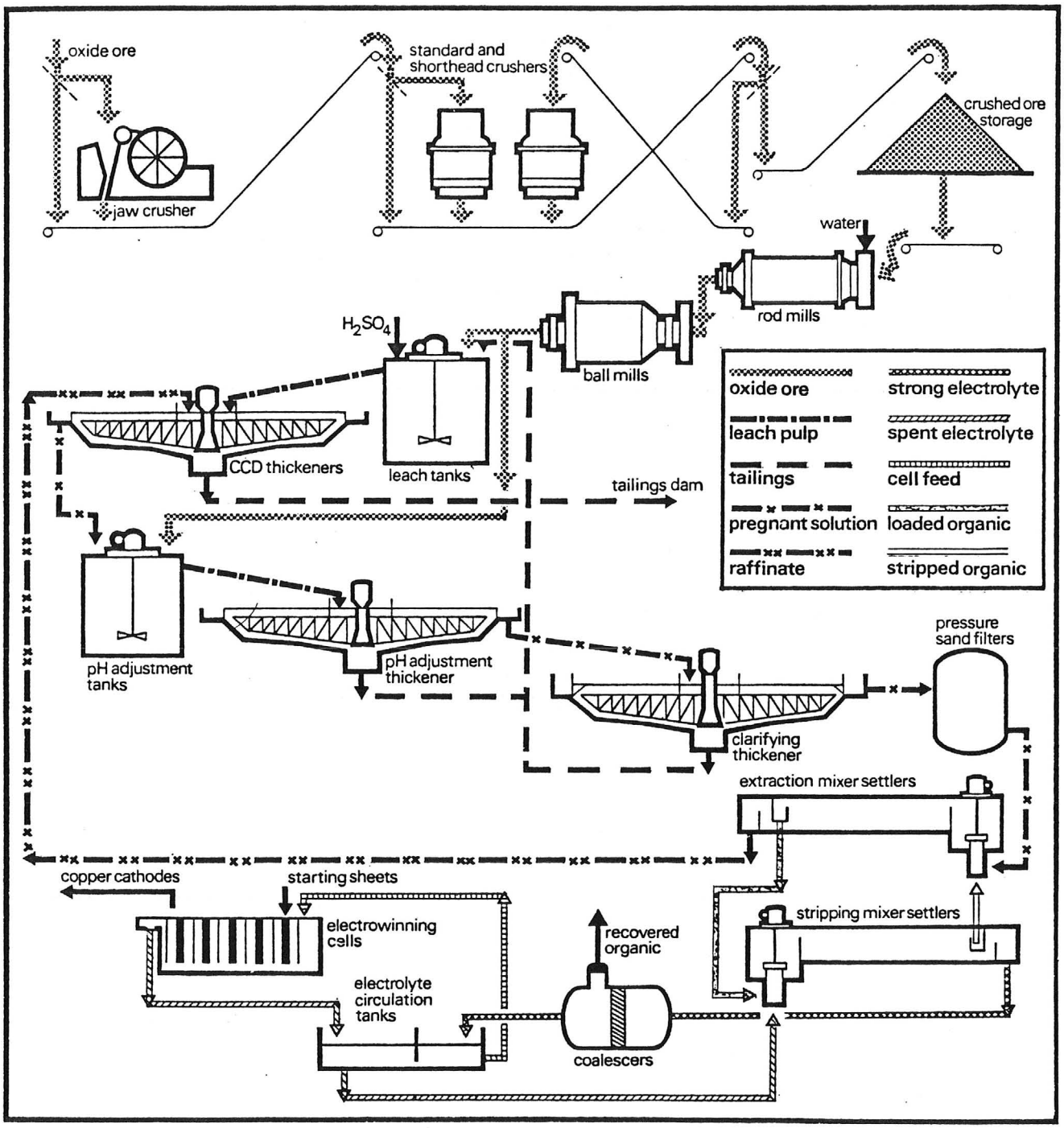

FIGURE 6. - Flow sheet of the proposed oxide leaching, solvent extraction, and electrowinning plant (after 14).

After a leaching period of five hours, the reacted material (at 50-percent solids) is pumped from the final leaching tank to the first in a series of four counter-current decantation wash thickeners (CCD thickeners), where the leach pulp is washed with barren aqueous liquor (raffinate) from the solvent extraction plant. The washed pulp and raffinate move in opposite sequence through the series of CCD thickeners so that the final underflow from CCD thickener No. 4 consists of tailings and the final overflow from CCD thickener No. 1 consists of the copper-rich pregnant solution. The tailings, at 50-percent solids, are partially dewatered by additional thickening before being pumped to the tailings disposal area.

The pregnant solution from the CCD thickeners, at a pH of 1.5 and containing about 0.01 percent solids [100 parts per million (ppm)], is pumped to three mechanically agitated pH-adjustment reactors (similar to the leach tanks) and mixed for 45 minutes with the unleached, one-tenth portion of the ground ore slurry in order to raise the pH to 2.5. The 10-percent solids slurry, after pH adjustment, is thickened to reduce the solids content of the solution to 0.05 percent (500 ppm) and clarified in a clarifying thickener to 0.008 percent (80 ppm). The underflow from both thickeners is returned to the leach tanks. The clarified solution is then filtered to 0.001 percent (10 ppm) solids in vertical downflow dual media pressure sand filters. The backwash recirculates to the pH adjustment tanks, and the filtrate goes to the solvent extraction plant.

In the solvent extraction plant, the pregnant solution, containing 0.030 troy ounces per gallon [2.5 grams/liter (g/l)] copper, is mixed in counter-current fashion in extraction mixer-settlers with a 14-percent solution of LIX 64 N organic extractant in kerosene, which extracts 68 percent of the copper from the pregnant solution. The "barren" aqueous liquor, or raffinate, containing the unextracted 32 percent of the copper is recirculated to the CCD thickeners where it again "picks up" another 100 percent load of copper by washing the leach pulp. The "loaded" organic extractant is stripped of its copper content by counter-current mixing in stripping mixer-settlers with spent electrolyte from the electrowinning plant. The stripped organic extractant is then recycled to the extraction mixer-settlers to load more copper. The regenerated electrolyte is transferred to the electrowinning plant.

The regenerated electrolyte releases any remaining entrained organic material in a coalescer feed reservoir before circulating through direct current electrolytic cells, where copper is deposited on cathodes. The cathodes are washed and stored for shipment to copper fabricators (f.o.b. mill).

Table 7 lists the equipment used in the mill (4, pp. 133, 135).

TABLE 7. - Equipment for oxide mill (from 14)

Equipment description	No. of pieces
Jaw crusher, 32- x 42-inch, Allis Chalmers	1
Cone crusher, standard, 5-ft, Allis Chalmers	1
Cone crusher, shorthead, 45-inch, Allis Chalmers	2
Rod mill, 7-by 12-ft, Denver	2
Ball mill, 9- by 14-ft, Denver	2
Leaching tanks, 24-ft diameter by 22-ft high	5
Reactors, pH adjustment, 6-ft diameter by 6-ft high	3
Thickeners, 250-ft diameter, counter-current decantation wash	4
Thickener, 250-ft diameter, clarifying	1
Filter, sand type, 12-ft diameter, 7-ft 9-inch high	3
Mixer settler, extraction	4
Mixer settler, stripping	2
Coalescer	1
Electrolyte circulation tank	4
Electrowinning cells	80
Cranes, for lifting cathodes	2

ECONOMIC EVALUATION

A Bureau of Mines cost-estimating handbook (24) was used to estimate most of the capital and operating costs for the mine, producing 33,069 short tons (30,000 mt) per day of sulfide ore (tables 8 and 9); the sulfide mill (tables 10 and 11); and the oxide mill, handling 4,106 short tons (3,725 mt) of feed per day (tables 12 and 13). Production schedules for all operations are 357 days per year, three shifts per day. Capital and operating costs for the elctrowinning section of the oxide mill are scaled on the basis of pregnant leach liquor flow rate from another mine using the same process. Land acquisition costs are based on published and unpublished figures for the purchase (merger) of Banner Mining Company (3), for the value of lands traded by Anamax for the Helvetia East property (17), and for purchase of the Empire Ranch (21). Infrastructure capital cost (the cost of installing a water supply system) was estimated by designing a hypothetical system and obtaining

current prices for component equipment and materials. Working capital for the mine and mills was estimated as the amount necessary to pay operating costs for 60 days of mine operation.

Financial analyses, using the MINSIM4 GENERAL program, determined that copper prices of 97.6 and 131.9 cents per pound ($2,152 and $2,908 per mt), respectively (appendix B), were required for break-even (0.0-percent) and 15.0-percent rates of return on investment. The cost of shipping sulfide concentrate to the San Manuel, Arizona, smelter and refinery is estimated to be $8.17 per short ton ($9.01/mt) of concentrate (24). Smelter and refinery operating costs of $85.29 per short ton ($94.02/mt) of copper sulfide concentrate and $168.97 per short ton ($186.26/mt) of blister copper, respectively, were used in the financial analysis. June 1978 byproduct metal prices used in the financial analysis are $183.93 per ounce ($5,913,486/mt) for gold and $5.32 per ounce ($170,908.84/mt) for silver.

TABLE 8. - Mine capital costs
(Design capacity: 30,000 mt of ore per day)

Description	Cost, June 1978 dollars
Land acquisition	$ 73,530,000
Exploration	5,790,500
Access roads	634,500
Preproduction development	30,590,200
Mine plant and buildings	4,659,800
Mine equipment	27,268,100
Engineering construction and management fees	4,574,100
Infrastructure	4,888,100
Environmental impact statement	100,000
Working capital	5,234,400
Total mine capital cost	$157,269,700

TABLE 9. - Mine operating costs
(Design capacity: 30,000 mt of ore per day)

Description	Cost, June 1978 dollars/mt
Direct cost:	
Production development	$1.633
Mining and hauling of ore	0.685
Restoration during production	0.071
General operations	0.151
Total direct cost	$2.540
Indirect cost:	
Administrative salaries and wages	0.227
Administrative purchases and equipment	0.056
Total indirect cost	$0.283
Fixed cost (including overhead, insurance, and local taxes)	0.085
Total mine operating cost	$2.908

TABLE 10. - Sulfide mill capital costs
(Design capacity: 30,000 mt of feed per day)

Description	Cost, June 1978 dollars
Crushing	$ 5,218,300
Grinding	15,267,400
Concentrating	4,002,100
Waste and tailings disposal	9,041,600
Site preparation	20,900
Utilities and facilities	20,630,700
Restoration during construction	377,600
Engineering and construction management fees	4,892,600
Working capital	3,907,800
Total sulfide mill capital cost	$63,359,000

TABLE 11. - Sulfide mill operating costs
(Design capacity: 30,000 mt of feed per day)

Description	Cost, June 1978 dollars/mt
Direct cost:	
Crushing	$0.233
Grinding	0.626
Concentrating	0.337
Waste and tailings disposal	0.116
Restoration during production	0.012
General operations	0.629
Total direct cost	$1.953
Indirect cost:	
Administrative salaries and wages	$0.135
Administrative purchases and equipment	0.020
Total indirect cost	$0.155
Fixed cost:	$0.063
Total sulfide mill operating cost	$2.171

TABLE 12. - Oxide mill capital costs
(Design capacity: 3,725 mt of feed per day)

Description	Cost, June 1978 dollars
Crushing	$ 1,396,200
Grinding	1,887,900
Concentrating and electrowinning	6,991,600
Waste and tailings disposal	2,644,700
Site preparation	2,700
Utilities and facilities	5,042,200
Restoration during construction	36,500
Engineering and construction management fees	1,775,900
Working capital	1,235,100
Total oxide mill capital cost	$21,012,800

TABLE 13. - Oxide mill operating costs
(Design capacity: 3,725 mt of feed per day)

Description	Cost, June 1978 dollars/mt
Direct cost:	
Crushing	$0.358
Grinding	0.643
Concentrating and electrowinning	3.252
Waste and tailings disposal	0.213
Restoration during production	0.012
General operations	0.632
Total direct cost	$5.110
Indirect cost:	
Administrative salaries and wages	$0.226
Administrative purchases and equipment	0.029
Total indirect cost	$0.255
Fixed cost:	$0.161
Total oxide mill operating cost	$5.526

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MINERALS AVAILABILITY SYSTEM
DEPOSIT SUMMARY REPORT

Helvetia West
Peach Elgin.

Anamax Mining Co.
by
Barbara J. West
Geologist
Intermountain Field Operations Center
January 1980

NOTICE

The views and conclusions contained in this document are the author's and should not be interpreted as necessarily representing the official policies or recommendations of the Interior Department's Bureau of Mines or the U.S. Government. The purpose of this report is to provide information for further review within the Bureau of Mines.

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STATE/CNTRY: Arizona | DISTRICT: Helvetia

COUNTY/PSD: Pima | COORD: N 31° 51' 50" W 110° 47' 50"

QUAD-SCALE: Sahuarita, 15 min | NAME: Helvetia West

COMMODITIES: Cu | SEQ. NO.: 004 019 0086

OWNER/OPERATOR: Anamax Mining Co.

TYPE: Open pit | STATUS: Prospect

OPERATION SUMMARY: Open pit 2,645 short tons (2,400 mt) ore per day plus 6,060 short tons (5,500 mt) of waste per day using 3 cubic yard loaders and 20 ton trucks, conventional sulfide flotation processing 2,645 short tons (2,400 mt) per day.

RESOURCES: 23,500,000 short tons (21,315,000 mt) of sulfide and oxide ore averaging 0.75% Cu

GEOLOGY: Pyrometasomatic deposit in Paleozoic limestones, ore mineralization-chalcopyrite, chalcocite, chrysocolla, bornite.

LAND HOLDING: unknown | STATUS: patented, fee ownership

DOMAIN: private | AREA POTEN. DISTURB: est. 1,441 acres (583 ha)

ENVIRONMENTAL FACTORS:	Short term:	Long term:
LAND:	moderate	moderate
WATER:	significant	significant
AIR:	nil	nil
FLORA:	insignificant	insignificant
FAUNA:	nil	nil
SOUND:	nil	nil
AESTHETICS:	significant	significant
OVERALL:	significant	significant

OPERATIONAL/ECONOMIC DATA: Estimated costs: Mine capital cost = $5,770,200, mine operating cost - $7.149/short ton ($7.883/mt) of ore, sulfide-flotation mill capital cost - $11,679,000, mill operating cost - $3.878 per short ton ($4.276 per mt) of ore.

Financial Analysis Summary

0% ROR

$1.27/lb ($2.80/kg)

15% ROR

$1.49/lb ($3.29/kg)

	OFFICE LOCATION	DC	CS	IA	E	I	W	A
FILES:	DATA SHEETS					X		
	BACKUP FILES					X		

EVALUATOR: B. West

INTRODUCTION

Anamax Mining Company is considering development of the Helvetia West copper property in the Santa Rita Mountains, southeast of Tucson, Arizona. The company expects to develop the property sometime in the future as an open pit mine and conventional sulfide flotation mill. The decision to go ahead with the project will be affected by national and international economics, supply and demand for copper, company needs for new sources of supply and numerous other factors involving such things as taxation, pollution laws, processing techniques, environmental matters and availability of reduction facilities.

This report describes the proposed mining and milling methods, details capital and operating costs [1/] for both the mine and mill, and determines a price per pound of copper for zero and 15-percent rates of return based on discounted cash flow analyses. All costs presented in the text are in January 1978 dollars.

OPERATION DATA

This section describes the location and ownership, history and environmental impact of the Helvetia West property.

Location and Ownership

The Helvetia West property is 25 miles [40 kilometers (km)] [2/] south of Tucson, Arizona, in the Santa Rita mountains. The deposit occurs in section 15 of T. 18 S., R. 15 E., Gila and Salt River Meridian, figure 1.

1/ Preliminary costing was done by Rick A. Salisbury and Paul Olmstead

2/ Numbers are presented in English units followed by the approximate metric equivalent in parentheses. Values are rounded; therefore, neither is precisely convertible to the other.

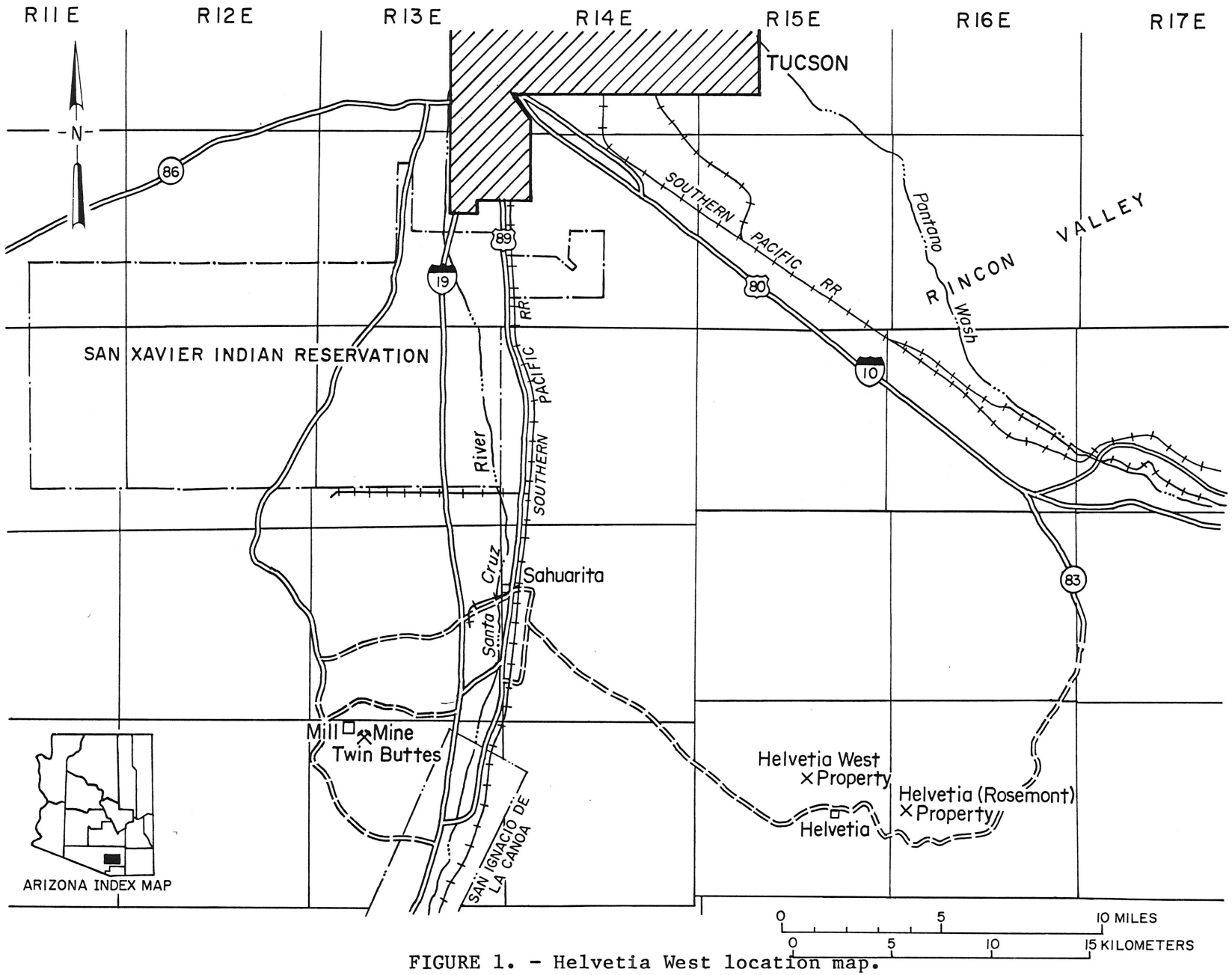


FIGURE 1. - Helvetia West location map.

The Helvetia property was originally leased by Anaconda from the Banner Mining Company of Tucson in 1964 (5). Today the Helvetia West property is owned by Anamax Mining Company, a new company formed from the union of Anaconda and Amax. In January 1977, Anaconda Co. ceased to exist as a separate and independent company when it was purchased by ARCO (11).

History

Mineralization in the Helvetia district was discovered as early as the 1870's. Small operations produced in the 1880's and 1890's. The Rosemont Copper Company and the Helvetia Copper Company produced from the 1890's to 1901. Except for a few years in the early 1930's, the district showed continuous but irregular production up through 1960 with the major output occurring during 1916-1919, 1944-1947 and 1957-1959. Since then there has been very little production (4).

Allan Bowman of Banner Mining Company in 1948 began acquiring as much property as possible in the area. Banner's exploration drilling on these properties partially delineated the Helvetia West orebody and discovered a major new orebody--Helvetia East over the mountains on the east slope (5). Helvetia East, another Anamax property, is presently progressing toward development.

Environmental Impact

The overall environmental impact of the Helvetia West project is expected to be moderate. The major impact to the land will occur during the mining and milling operations. The largest single visible impact will be the open-pit mine. The resulting excavation will be about 3,700 feet [1,128 meters (m)]

long, 2,200 feet (671 m) wide, and about 1,200 feet (366 m) deep. Most of the rock that is mined will be discarded in waste dumps or in mill tailings. The tailings and dumps will cover about 1,300 to 1,400 acres [526 to 567 hectares (ha)] of land. Forty-one acres (17 ha) of land will be significantly impacted by onsite road construction and site preparation.

The principal sources of atmospheric pollution will consist of dust and noise generated by vehicular traffic, blasting, loading of overburden and ore, and crushing operations.

GEOLOGY

The Helvetia mining district lies at the northern end of the Santa Rita Mountains to the southeast of Tucson. Precambrian schist and granodiorite are unconformably overlain by a thick sequence of Paleozoic marine deposits including quartzite, limestone, shale and sandstone. Mesozoic volcanics and sediments unconformably overlie the Paleozoic sequence. Strong deformations by folding and faulting took place during the middle to late Mesozoic and were accompanied by igneous intrusions. Normal faulting continued almost up to recent times.

The majority of the orebodies are of the pyrometasomatic or contact metamorphic type in lime-silicated Paleozoic limestones along or close to the contact with late Laramide quartz latite porphyry intrusions or along fault zones. The orebodies that have been mined were generally small and highly irregular in outline. Copper is the dominant metal in the district but some lead and zinc is usually present. Molybdenum and tungsten have more erratic values. Silver values are often high but gold values are uniformly low. Most of the deposits have been oxidized to various depths (8).

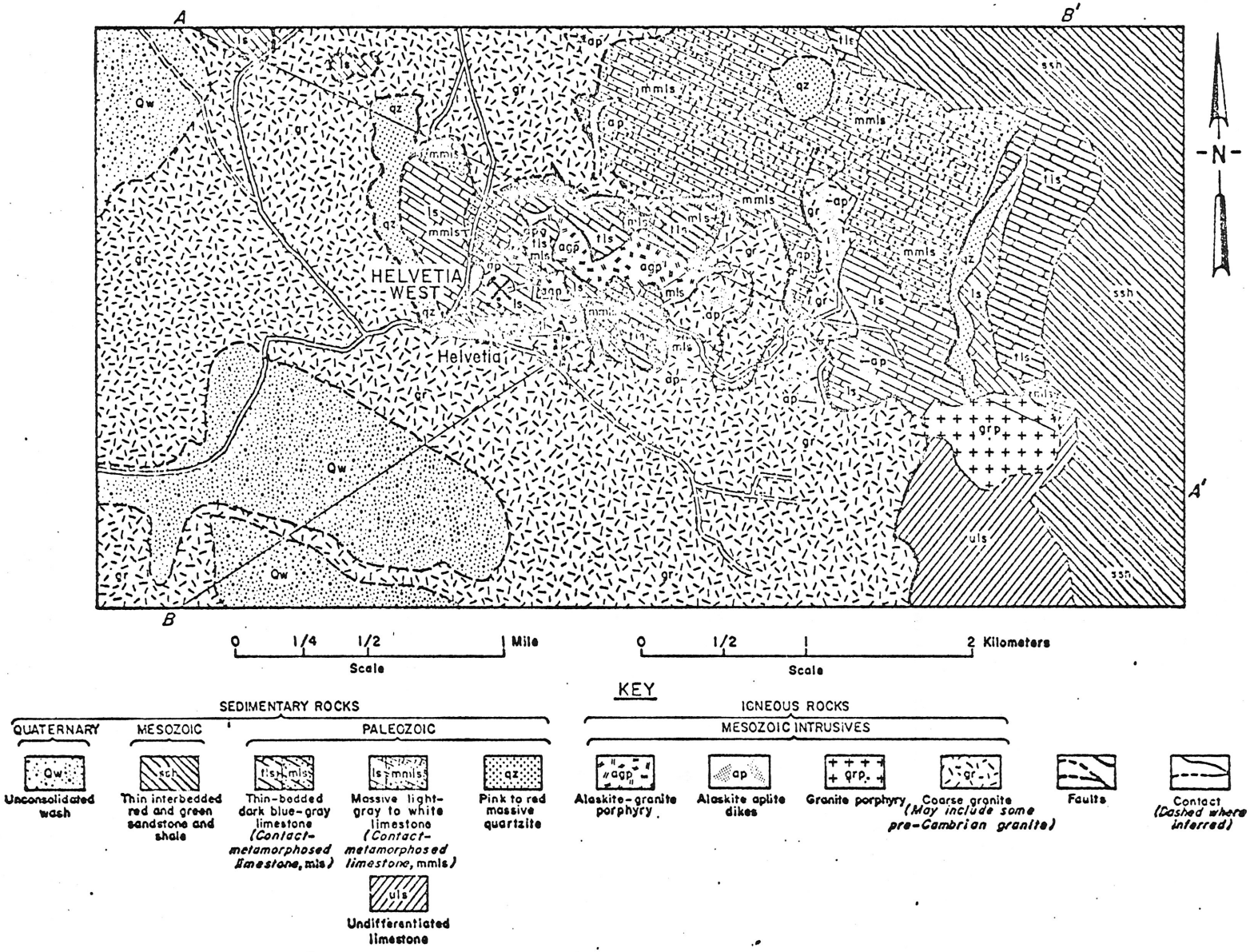
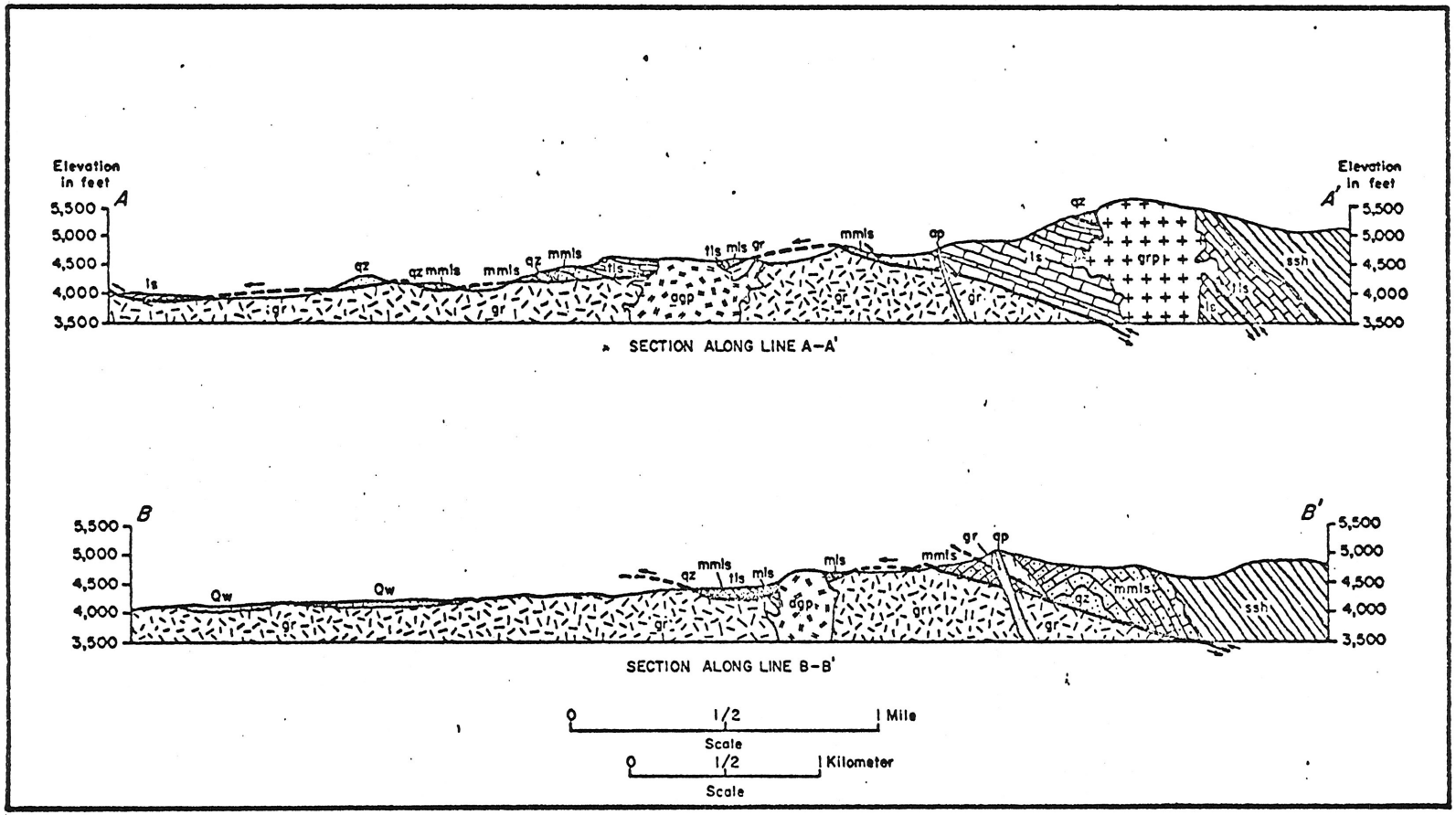


FIGURE 2. - Geologic map of the Helvetia area.



KEY

SEDIMENTARY ROCKS

QUATERNARY

Qw — Unconsolidated wash

MESOZOIC

ssh — Thin interbedded red and green sandstone and shale

PALEOZOIC

tls mls — Thin-bedded dark blue-gray limestone (Contact-metamorphosed limestone, mls)

ls mmls — Massive light-gray to white limestone (Contact-metamorphosed limestone, mmls)

qz — Pink to red massive quartzite

IGNEOUS ROCKS

MESOZOIC INTRUSIVES

gqp — Alaskite-granite porphyry

ap — Alaskite aplite dikes

grp — Granite porphyry

gr — Coarse granite (May include some pre-Cambrian granite)

Faults

FIGURE 3. - Geologic cross sections through the Helvetia area.

Three-cubic-yard (2.3-cu-m) loaders and 20-short-ton (18-mt) end-dump trucks will be used for loading and hauling rock. The proposed stripping ratio is slightly less than 2.3:1, waste to ore. Rotary drills will be used for drilling; ANFO will be used for blasting. The powder factor will be approximately 0.35 pounds per short ton [0.14 kilograms (kg) per mt]. The proposed bench height is 50 feet (15 m). Average haul distances will be about 2,461 feet (750 m) with an 8-percent average grade.

Because of variations in the distribution of oxide and sulfide ore, a detailed assaying and metallurgical testing program is planned. The program will consist of sampling each blast hole's cuttings except in overburden areas. Each sample will be analyzed. If the ore can be effectively treated by flotation it would be sent to the mill for processing. However, if the ore contains primarily oxide mineralization it will be stockpiled on a dump area for possible future processing; if the copper content is below that which can be economically processed, the material will be dumped in a waste area.

BENEFICIATION

The ore will be processed by conventional flotation methods at a rate of 2,645 short tons (2,400 mt) per day. The mill will operate 350 days per year and three shifts per day.

Crushing Section

All ore will be transported to the primary jaw crusher for reduction to 2-inch [5-centimeter (cm)] size. The ore will then be fed to a secondary cone crusher for further reduction to 0.38- to 0.63-inch (0.97- to

Copper mineralization in the Helvetia area consists of chalcopyrite, chalcocite, chrysocolla, "copper pitch" and bornite with associated pyrite, magnetite and iron oxides (3).

RESERVES

Reserves entered on the Minerals Availability System resource matrix for the Helvetia West deposit are 1978 data, Appendix A. Proven ore reserves (90 percent probability) amount to 10,000,000 short tons [9,070,000 metric tons (mt)] of oxide ore at 0.72 percent copper and 13,500,000 short tons (12,245,000 mt) of sulfide ore at 0.78 percent copper for a total of 23,500,000 short tons (21,315,000 mt) of oxide-sulfide ore averaging 0.75 percent copper (7). No grades for molybdenum, silver or gold are available; however, it is believed that they occur in at least trace amounts.

At present there are no plans to process the oxide ore; instead, it will be stockpiled. In the future they might consider sending it to Twin Buttes, Arizona.

PROPOSED MINING SYSTEM

Because this property is nonoperating, detailed data are lacking. Therefore, an estimate of the proposed mining methods is presented. This estimate is based on company data, published information and the U.S. Bureau of Mines "Capital and Operating Cost Estimating Handbook" (10). Also, much of the data presented may be changed by the time operations begin at the property.

At whatever future point Anamax begins operations, the company plans to mine 2,645 short tons (2,400 mt) per day of ore and approximately 6,060 short tons (5,500 mt) of waste. The mine will be operated 350 days per year, three shifts per day.

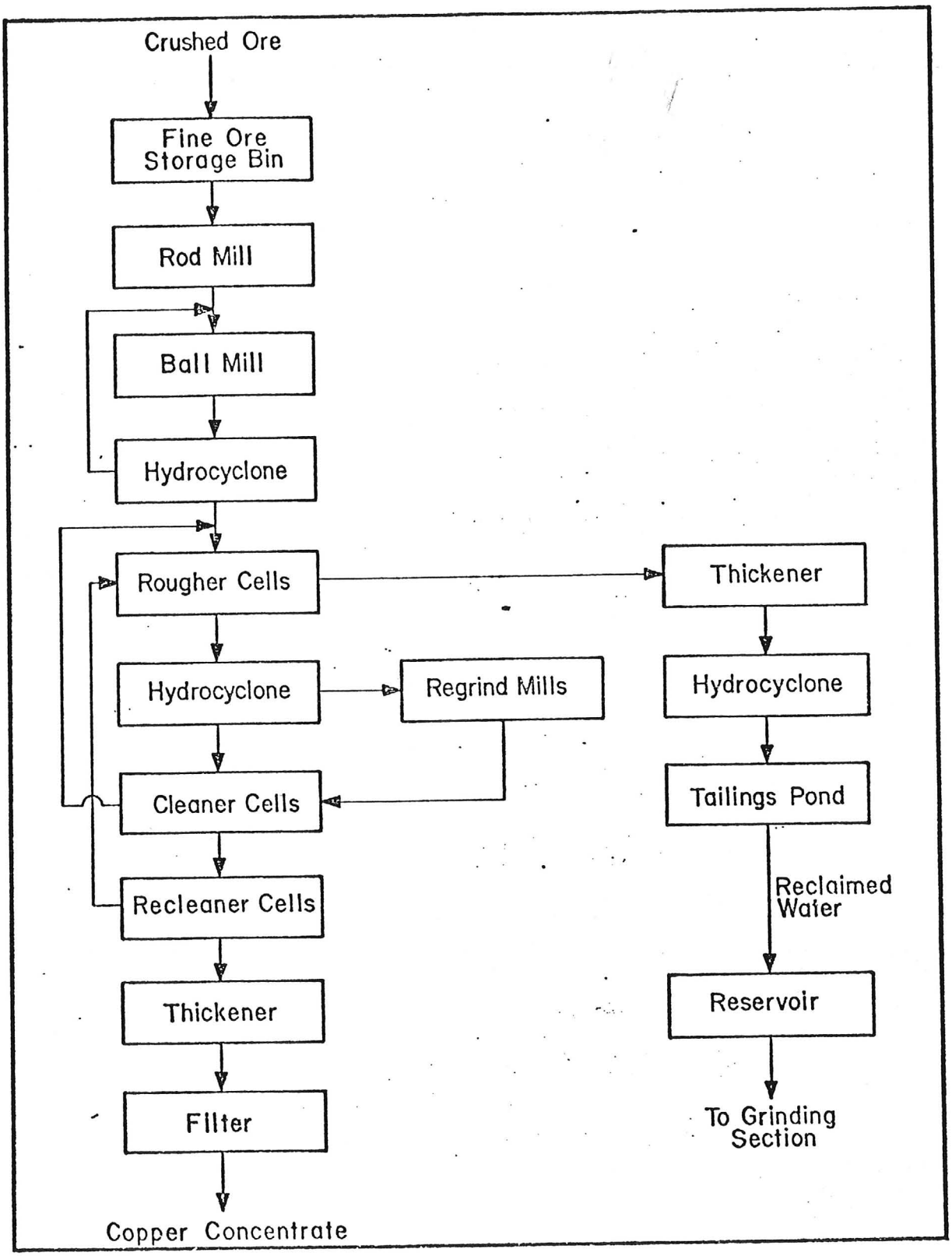


FIGURE 4. - Proposed generalized beneficiation flowsheet for Helvetia West.

1.60-cm) size. The crushed ore will then be sampled and sent to the sulfide-ore bins, figure 4.

Grinding Section

Crushed ore will be transported from the sulfide ore bin to the grinding section. The ore will then be wet ground in rod mills operating in open circuit and in ball mills grinding in closed circuit with hydrocyclones. Overflow from the hydrocyclones will go to flotation.

Flotation Section

The flotation section will be composed of rougher, cleaner, and recleaner units in which the slurry will be upgraded to a copper concentrate. Slurry from the grinding section will flow to the roughers where flotation will begin. The tailings from the roughers will flow by gravity to the tailings thickener, and rougher concentrate will be pumped to hydrocyclones. The underflow will be fed to regrind mills, and the overflow will be pumped to the cleaning flotation cells. Concentrate will be produced in the first few cells. Concentrate from the last cells will be fed to the recleaner cells for further cleaning with the cleaner rejects being returned to the grinding section.

The concentrate will then be further upgraded in the recleaner section. Recleaner rejects will be returned to the cleaner feed, and the final copper concentrate will flow to the thickener. The underflow will be pumped to the filters, then the filtered concentrate cake will be conveyed to a storage area.

Copper Filter Section

The copper concentrate will be transferred to the copper-filter section for dewatering and preparation for shipment to a smelter.

Lime Preparation Section

Lime will be slaked in a ball mill operating in closed circuit with a hydrocyclone to produce a slurry which will be pumped to storage tanks and then circulated to rougher flotation.

Tailings Disposal

The final plant tailings will be pumped to the tailings thickener; the thickener overflow will be returned to the mill for use as process water. The pulp will then be pumped to hydrocyclones where the overflow goes to the tailings pond, and the underflow goes to the tailings dam. The reclaimed water from the tails will be pumped to a reservoir for storage and then to the mill for use as process water.

ECONOMIC EVALUATION

The economic evaluation made for the Helvetia West project consists of estimated capital and operating costs for mining and beneficiation. The costs were derived by compiling data from curves, cost factors, and equations in the U.S. Bureau of Mines' Capital and Operating Cost Estimating System Handbook (10). All costs are January 1978 dollars.

Estimated Mine Capital Cost

The estimated mine capital cost, based on a daily ore tonnage of 2,645 short tons (2,400 mt), is $5,770,200, table 1.

TABLE 1. - Estimated mine capital cost

Cost items	Total cost
Exploration	$265,700
Access roads	55,600
Preproduction development	364,700
Mine plant and buildings	914,400
Restoration during construction	29,500
Mine equipment	2,618,000
Engineering and construction management fees	387,100
Working capital	1,135,200
	$5,770,200

Estimated Mine Operating Cost

The mine operating cost, based on a daily production of 2,645 short tons (2,400 mt) of ore, is estimated to be $7.149 per short ton ($7.883 per mt), table 2.

TABLE 2. - Estimated mine operating cost

Cost items	Cost/short ton	Cost/metric ton
Production development	$3.361	$3.706
Mining of ore	1.829	2.017
Restoration during production	0.112	0.123
General operations	1.510	1.665
Administative costs	.337	.372
TOTAL ANNUAL OPERATING COSTS	$7.149	$7.883

Estimated Beneficiation Capital Cost

The estimated beneficiation capital cost, based on a single-product flotation section and a daily ore tonnage of 2,645 short tons (2,400 mt), is $11,679,000, table 3.

TABLE 3. - Estimated beneficiation capital cost

Cost items	Total cost
Crushing	$1,205,900
Grinding	3,346,800
Concentrating	1,079,600
Waste and tailings disposal	635,400
Clearing	18,800
Utilities and facilities	3,719,200
Restoration during construction	17,700
Engineering and construction management fees	1,039,900
Working capital	615,700
TOTAL CAPITAL REQUIRED	$11,679,000

Estimated Beneficiation Operating Cost

The estimated beneficiation operating cost, based on a single-product flotation section and a daily feed tonnage of 2,645 short tons (2,400 mt), is $3.878 per short ton ($4.276 per mt), table 4.

TABLE 4. - Estimated beneficiation operating cost

Cost items	Cost/short ton	Cost/metric ton
Crushing	$0.302	$0.333
Grinding	1.442	1.590
Concentrating	.818	.902
Waste and tailings disposal	.116	.128
Restoration during production	.023	.025
General operations	.893	.985
Administrative	.284	.313
TOTAL BENEFICIATION OPERATING COST	$3.878	$4.276

ECONOMIC ANALYSIS

The economic analysis was made by using the MAS MINSIM4 computer program. Results of the economic analysis show a breakeven operation at a copper price of $1.27 per pound ($2.80 per kg) copper. The prices of copper necessary to obtain a 0- and 15-percent rate of return were determined, table 5.

TABLE 5. - Economic analysis

Rate of return	Price/lb	Price/kg
0%	$1.27	$2.80
15%	1.49	3.29

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APPENDIX A

Appendix A is a computer printout of the Helvetia West file from the MAS data base. Information in the data base is in metric units. Further details and explanation of entries are in the MAS data base manual.