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James Doyle Sell Mining Collection

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Circulate to SWED

FACT SHEET

DUVAL CORPORATION - SIERRITA - ESPERANZA - CLEAR

DAILY TONNAGE -	Milled	92,000 Dry Short
	Mined	230,000
ORE GRADE -	Cu.	0.34%
	Mo.	0.038%

Note: When Esperanza mill is running we mill an additional 18,000 per day and mine an additional 40,000.

TOTAL EMPLOYEES

Sierrita----------	2,036
*Esperanza---------	89
**CLEAR ----------	201
TOTAL	2,326

* When Esperanza mill is operating an additional 300 employees are required. These people now at Esperanza operate the dump leaching system and furnish a special maintenance group for projects at Sierrita.

The total benefits package increases salaries and wages by 38%.

The average hourly wage is $7.95/hr. The beginning hourly wage - inexperienced laborer - $6.53/hr.

All groups are represented by unions with Steelworkers, Operating Engineers, Teamsters, and Laborers, jointly certified. IBEW represents the electrical group.

** CLEAR is Duval's own patented process for hydrometallurgical treatment and recovery of copper from sulphide concentrates. The acronym stands for "Copper Leach Electrolysis and Regeneration". This plant is not yet open to visitation without prior approval of Corporate management.

SALARIES AND WAGES PER MONTH--- 000's omitted

Sierrita----------	$ 3,404
*Esperanza---------	136
CLEAR----------	340
	$ 3,880

*Increases by $600,000 with Esperanza operating

All power is purchased from Tucson Gas and Electric Company. Presently costs about $2,253,000 per month and increases by $1,200,000 when Esperanza mill is running.

PRODUCTS - Average Month (Sierrita only)

Cu. ----------	17,100,000 Lbs.
Mo. ----------	1,500,000 Lbs.
Ag. ----------	90,000 Oz.

ASARCO

Southwestern Exploration Division

JDS

August 15, 1985

To: W. L. Kurtz

From: J. D. Sell

Bob Metz says that Inspiration Resources and a Japanese group will probably announce that they have bought the Duval Sierrita-Esperanza complex. The Japanese name was "Sumitomo," which is the same which is now rumored in the journals to take a less than 30% interest in Morenci Phelps Dodge, rather than more. Perhaps this Sierrita deal is the reason for less interest in Morenci?

James D. Sell

J. D. Sell

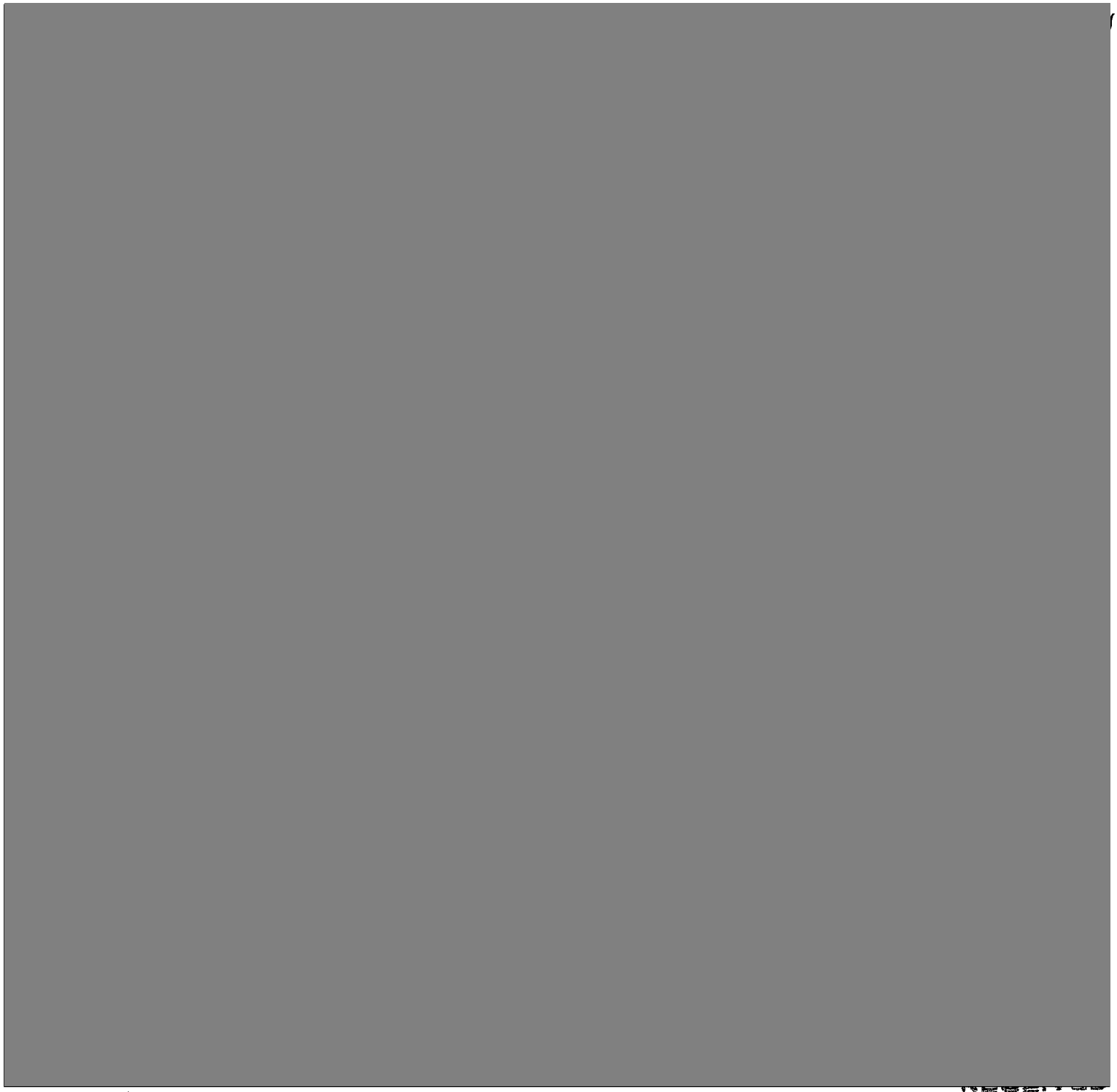
JDS:mek

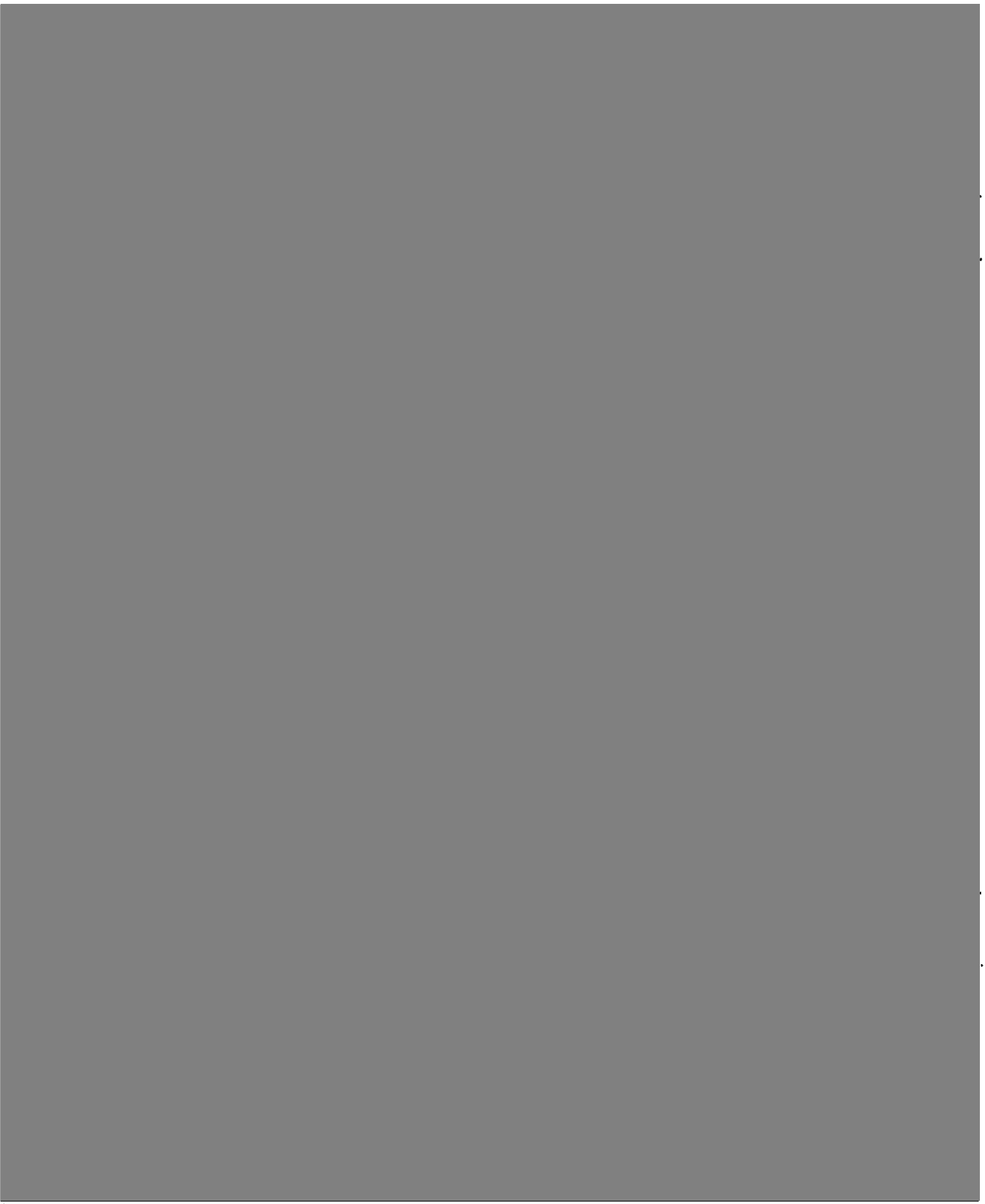
Geochimica et Cosmochimica Acta Vol. 52, pp. 2235–2249

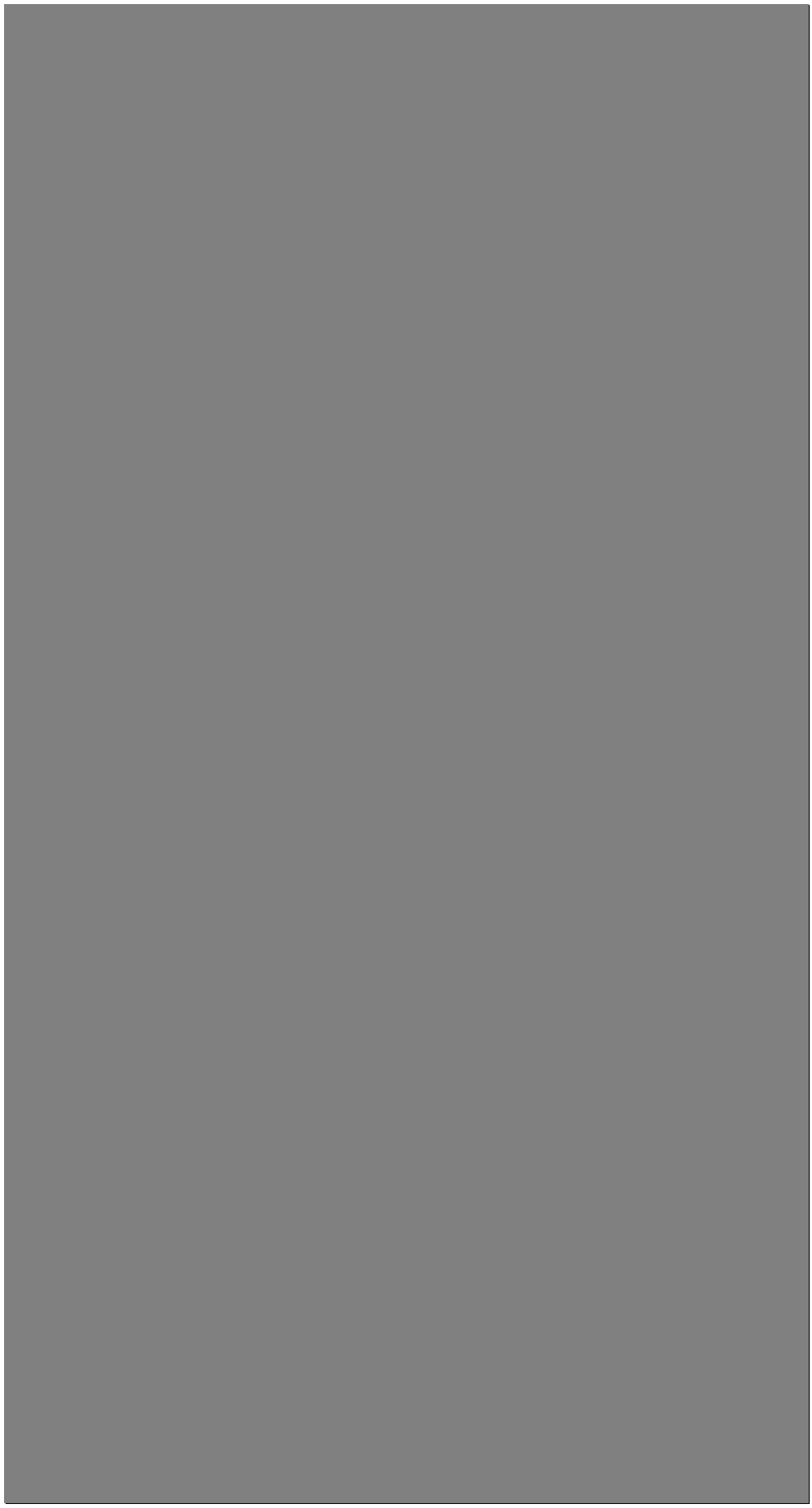
0016-7037/88/$3.00 + .00

Progressive mixing of isotopic reservoirs during magma genesis at the Sierrita porphyry copper deposit, Arizona: Inverse solutions

ELIZABETH Y. ANTHONY* and SPENCER R. TITLEY
Department of Geosciences, University of Arizona, Tucson, AZ 85721, U.S.A.







1/1x/89 As Spence says:

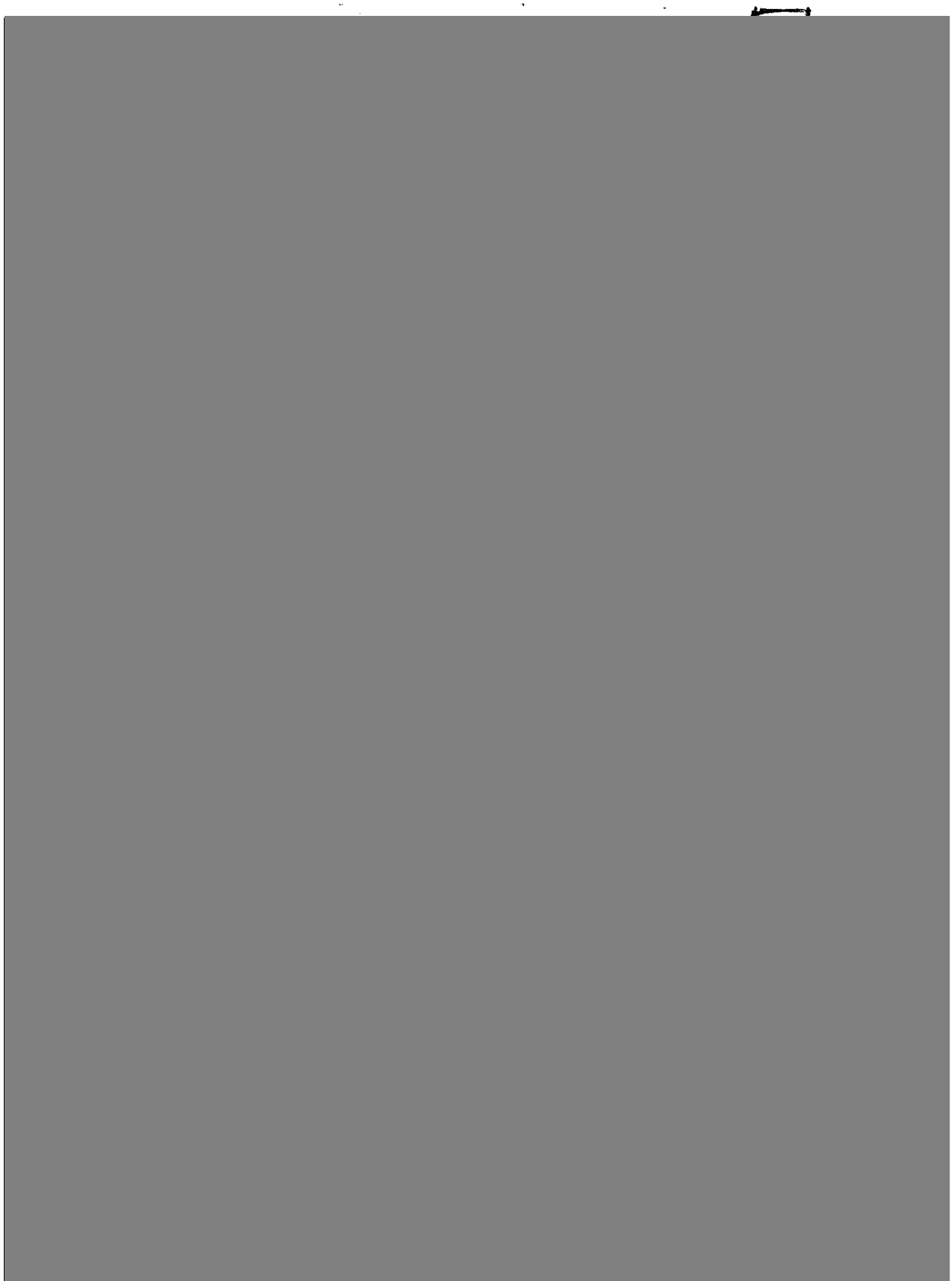
This data suggests the porphyry system components, ie Cu & Mo etc were derived from the crust. Thus not subduction related per se as they (+-sediments) has essentially no mantle characteristics.

[redacted]

P. 2

The Morning Record, V. 83, No. 49, p. 1
Wed., December 4, 1972.

Also
Sep
P. 2



File Duval

J. H. C.
MAR 22 1971

VISITOR'S INFORMATION

DUVAL SIERRITA CORPORATION

SIERRITA PROPERTY

SAHUARITA, ARIZONA

SIERRITA PROPERTY

The Sierrita property consists of over 13,000 acres, which includes property rights for water field, tailing disposal and rights of way for pipelines and a railroad spur. Included in this total acreage are 143 unpatented mining claims which were purchased by Duval. Approximately 58 percent of the Sierrita ore body was acquired in the purchase of these claims. The remaining 42 percent of the ore body was controlled by patented mining claims owned by Duval. Duval has transferred these patented claims to the Sierrita property.

EXPLORATION AND PRELIMINARY DEVELOPMENT

A total of 178 test holes has been drilled in order to delineate the Sierrita ore body and to test proposed waste dump areas. Some of the tests were drilled to check certain holes drilled by another mining company, which had previously drilled 60 core tests in the area.

GEOLOGY

Rock types within the ore zone consist of quartz diorite, quartz monzonite, and quartz monzonite porphyry. Metallization, partly syngenetic, consists of chalcopyrite and molybdenite with minor amounts of sphalerite, galena and magnetite. There is no enriched blanket in the Sierrita ore body. Dominant structural trend is NE to ENE.

ORE RESERVES

The exploration and preliminary development program delineated an ore body of 414 million tons with an average copper content of 0.35% (seven pounds) and an average molybdenum content of 0.036% (0.72 pounds). Engineering pit design indicates that a total of 634 million tons of waste must be handled prior to and during the mining of the 414 million tons ore reserve. This total of over a billion tons of ore and waste, which will be mined, represents more than twice the tonnage excavated in the construction of the Panama Canal.

Continued...

MINING

It is anticipated that the eventual perimeter of the Sierrita open pit will encompass an area of approximately 460 acres. As presently designed, the pit will ultimately reach a depth of 1850' below the highest elevation of the pit area prior to mining. Such an ultimate depth will represent a distance of almost one and a half times the height of the Empire State Building.

One hundred and twenty-six (126) million tons of waste was removed during the pre-mine stripping period prior to the startup of the mill. A daily average of 200,000 tons per day was mined during the pre-mine stripping period. The mining of ore and waste will be conducted on this scale for an initial six-year production period, after which the scale of mining operations will be somewhat reduced as less waste will be handled.

Mining is accomplished by establishing a series of levels or benches. Each bench is approximately fifty (50) feet high. The large power shovels are provided digable material by blasting the various benches. To blast a bench, rotary drills drill holes 59' in depth and from 9" to 12¼ " in diameter.

The blast holes which contain water, are loaded with a gelatin explosive called slurry. The holes which are dry, are loaded with ammonium nitrate and fuel oil.

A typical blast consisting of forty (40) holes requires 76,000 lbs. of explosive to break 200,000 tons of rock. This is enough material to keep one electric shovel in production for approximately four (4) days.

MINING EQUIPMENT AND FACILITIES

The mining equipment features six (6) power shovels of P & H manufacture equipped with 15 cubic yard buckets and 32 electric wheel haul trucks of 120-ton capacity, which will be expanded to 36 within the next few months. These shovels and trucks are of the largest presently used in the copper mining industry. In addition six rotary

Continued...

MINING EQUIPMENT AND FACILITIES CONTD

blast-hole drills (two 60-R, three 45-R, and one CP 750), 12 dozers (three D-9, five D-8, and four rubber tired), and numerous other units; such as, 3 motor patrols, 2 forklifts, 1 crane, 4 water trucks 4 personnel buses and miscellaneous small trucks supplement the operation. Service facilities consist of two modern shops, steam cleaning pad, change room, and offices.

Because the power shovels and haul trucks represent the largest of these machines used in the industry, some pertinent facts concerning these units are of interest:

Power Shovels

1. The weight of each shovel is approximately 450 tons.
2. Shovels are rated at 750 HP and are electrically powered by 4160 volt AC current.
3. When loaded the 15 cubic yard bucket contains approximately 23 tons.

Haul Trucks

1. The truck fleet consists of 14 from KW Dart Company and 18 from Westinghouse Air Brake Company.
2. The truck engines are 12-cylinder diesels, rated at 1000 HP.
3. The engine drives the electric generator, which supply power to electric motor assemblies in the rear wheels.
4. Trucks have a rated capacity of 120 tons and weigh approximately 75 tons empty.
5. Fuel tanks hold 450 gallons of diesel oil; the engines use one gallon per mile under full load conditions and level haul.
6. Truck tires are constructed of 48-ply; stand nine feet in height, and weigh 3000 pounds.
7. The expected life of each truck is 5 to 7 years after which replacement is anticipated.

Continued...

PLANT FACILITIES

Stearns-Roger Corporation of Denver, Colorado, was the engineering construction contractor that designed and built the Sierrita concentrator and associated facilities. The concentrator, which has a designed capacity of 72,000 tons of ore per day, and the associated facilities are estimated to cost 100 million. This capacity will be greater than any single copper-molybdenum concentrator in North America. The construction of plant facilities was completed in the first quarter of 1970.

CRUSHING

Primary size reduction of the mined ore is achieved by two 60" x 89" gyratory crushers located near the south perimeter of the Sierrita open pit and adjacent to the main haulroad. The crushers have a total operating capacity of 5,000 tons per hour, reducing the mine ore to about 85% minus 6". The crushed ore is transported by a 54" belt conveyor system to a 40,000-ton coarse ore open storage - an overland distance of about 2½ miles.

Feeder belts under the coarse ore pile collect the ore to feed the fine crushing plant. Ore is first fed to four vibrating double deck scalping screens ahead of four 13 x 84 hydrocone secondary crushers. The secondary crusher product is again screened and the oversize material is further reduced by eight 5 x 84 hydrocone tertiary crushers operating in a closed circuit system consisting of a 2400-ton surge bin feeding the crushers and vibrating screens. The finished product, essentially all minus ½", is transported to a 72,000-ton live capacity fine ore bin located in the concentrator building.

CONCENTRATING

The process of flotation is used to concentrate the copper and molybdenum minerals. To accomplish this, the crushed ore must be further reduced by grinding it to achieve

Continued...

CONCENTRATING CONTD

mineral liberation to effectively concentrate it by floating these mineral particles. Copper and molybdenum are concentrated simultaneously and then separated.

The ore from the fine ore storage is wet ground in fourteen 16½' diameter by 19' ball mills driven by 3,000 horsepower synchronous motors. The ball mills operate in a closed circuit with cyclone classifiers. The ground ore in an ore-water slurry and conditioned with reagents is floated in flotation machines to a rough concentrate of copper and molybdenum minerals. The rougher concentrate is reground in two 11' diameter by 15' regrind ball mills that are operated in a closed circuit with cyclone classifiers. The rougher concentrate is floated and refloated to a final concentrate. A total of 602 flotation machines is used in the copper-molybdenum concentration. Tailings from the flotation process are thickened before disposal in four 350' diameter rake thickeners and the water is recovered from the slurry for re-use in the process. The concentrates are thickened in 100' diameter thickeners.

The combined copper-molybdenum concentrate is floated to separate the two products. The pulp is first steamed and then conditioned with reagents before flotation. In the first flotation, the copper minerals are depressed and the molybdenum floated. The copper concentrate is the tailings from this flotation and after thickening in a 125' diameter thickener, it is filtered in four drum filters and loaded in open gondola railroad cars for transporting to the smelter. The molybdenum is concentrated more by floating it in cleaning and re-cleaning stages. The final molybdenum concentrate is filtered, dried, and stored for packaging for marketing as molybdenum sulfide or for roasting it in two 23½' diameter multiple hearth roasters. The roasted product, molybdenum trioxide, is packaged and marketed as technical molydic oxide.

PRODUCTION

The Sierrita property will produce an annual average of 130 million pounds of copper during the first five years of operation and 150 million pounds thereafter. In addition, the property will produce approximately 13 million pounds of molybdenum and 500,000 ounces of silver annually. With Sierrita's production, Duval Corporation will rank fourth in U. S. copper mine production and will be the second largest producer of molybdenum in the U. S.

EMPLOYMENT

Peak employment during construction at the Sierrita property was 1800. The average permanent employment during production will be 1100.

UTILITIES

Power and gas will be supplied by Tucson Gas and Electric Company. Power requirements are expected to be approximately 60,000 kilowatts or 40 million kilowatt hours per month. This amount of power would supply an average city of 100,000.

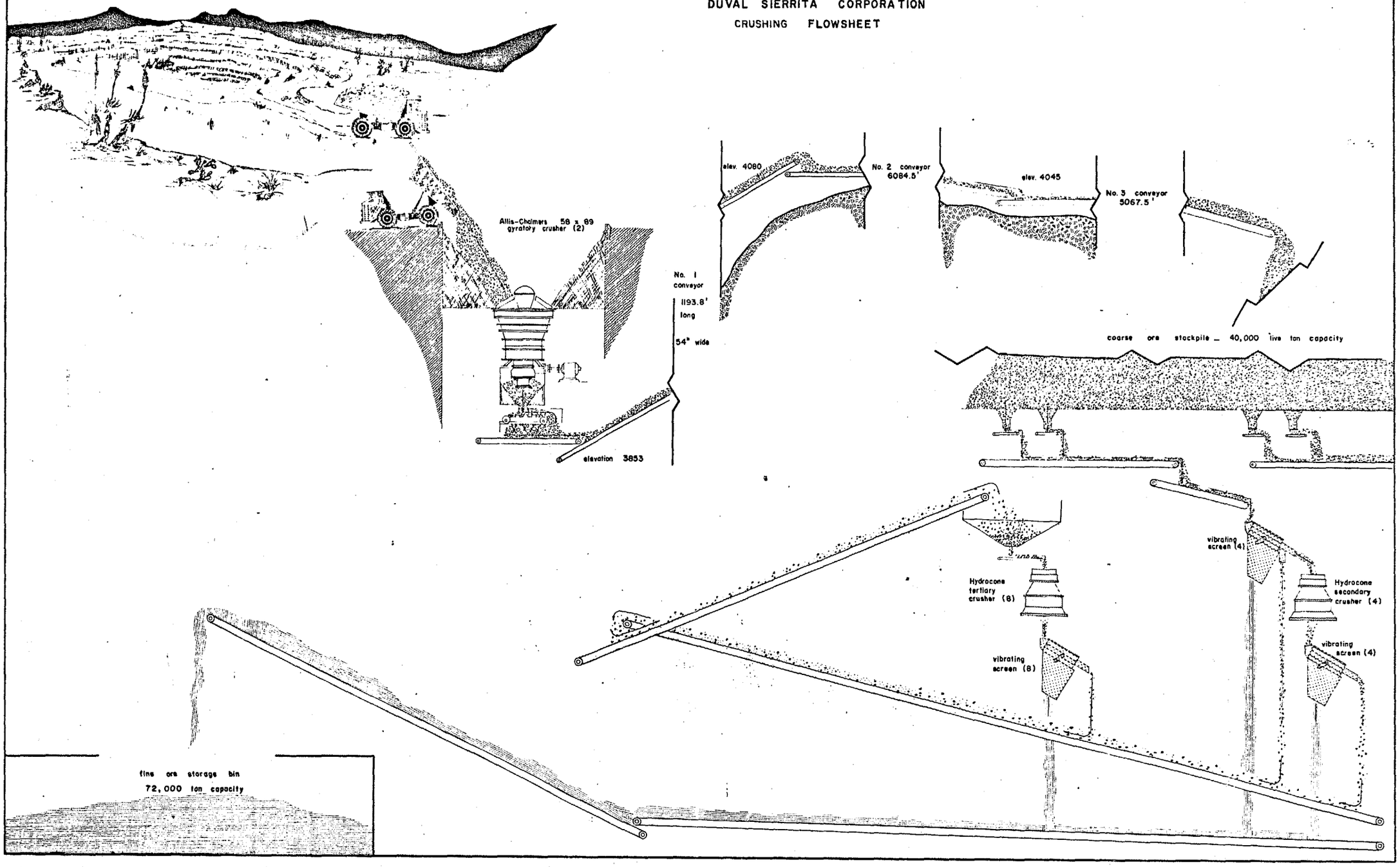
Gas requirements are expected to be some 50 million cubic feet per month with all but a fraction of the gas being utilized in roasting molybdenum sulphide concentrates into the oxide form.

Water requirements for the operation will be on the order of 15,000 gallons per minute with most of this amount being used in the milling operation. This water will be pumped from wells along the Santa Cruz River basin belonging to the Sierrita property. To secure this advantageous site with its water rights, a 5900-acre ranch, which was part of an original Spanish Land Grant, was purchased.

jeg
6-26-70

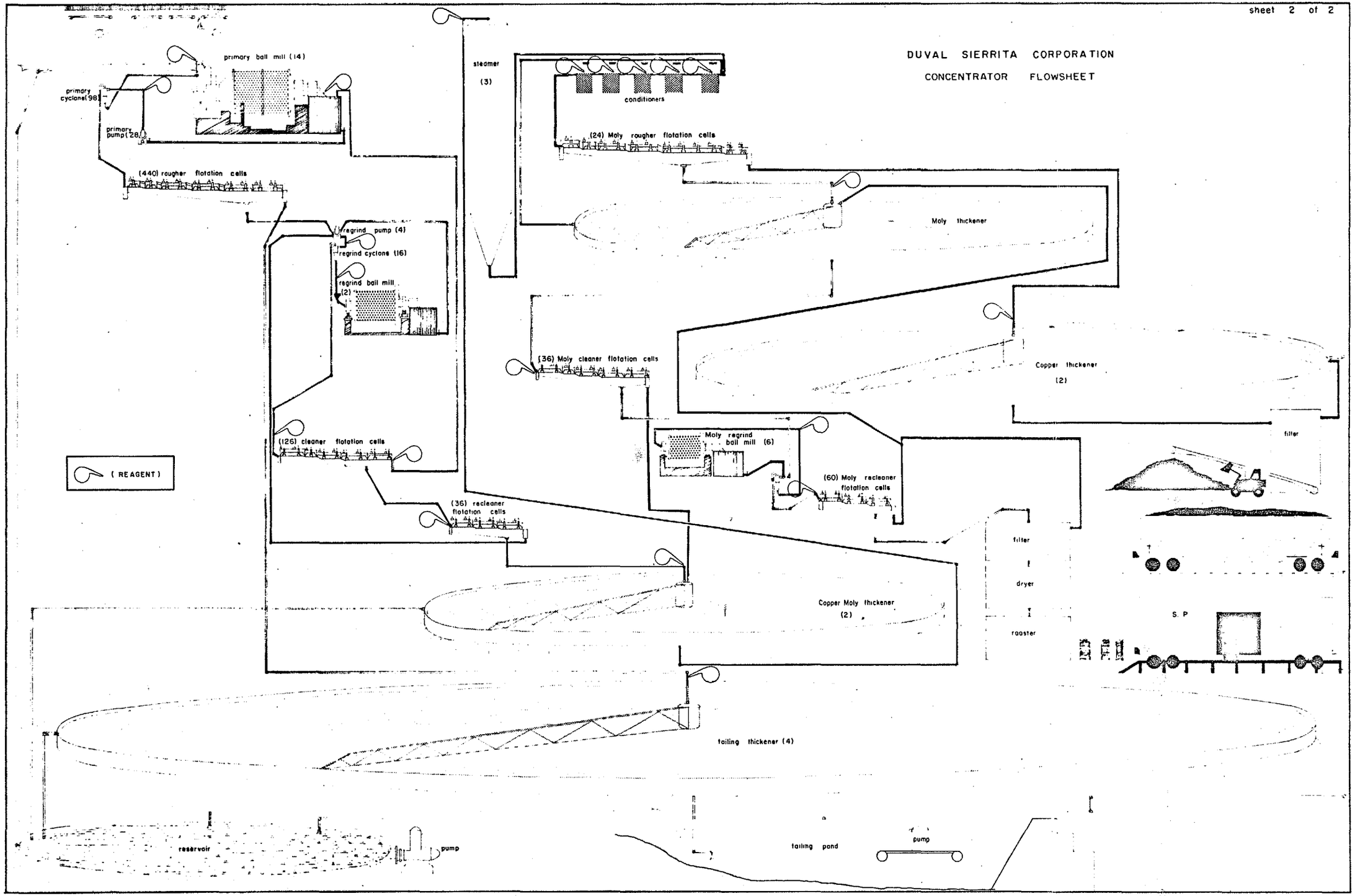
DUVAL SIERRITA CORPORATION

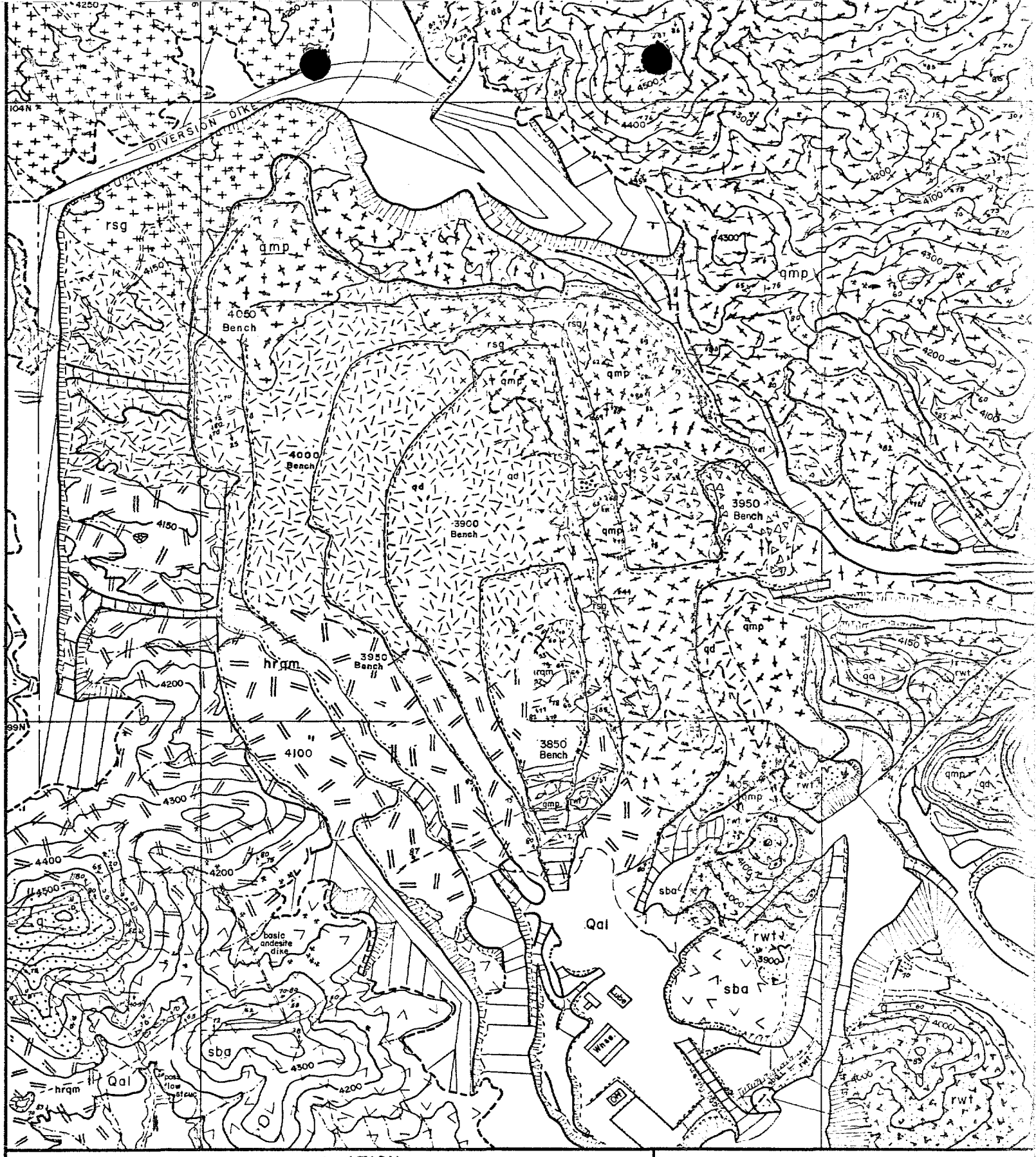
CRUSHING FLOWSHEET



DUVAL SIERRITA CORPORATION

CONCENTRATOR FLOWSHEET





EXPLANATION

- Qal — Alluvium, waste dumps,
- [dotted] — Aplite
- [blank] — Massive quartz veins
- qlp — Quartz latite porphyry
- qmp — Quartz monzonite porphyry
- rsg — Ruby Star granodiorite
- sba — Silver Bell (Demetrie) andesite
- qd — Biotite quartz diorite
- hrqm — Harris Ranch quartz monzonite
- rwt — Oxframe rhyolite welded tuff
- q — Quartzite

DUVAL SIERRITA CORPORATION

SIERRITA PIT GEOLOGY

SCALE: 1" = 1,000'	DATE: 12-1-70
GEOLOGY BY RAM, AHJ, BLW, DWL, FWM.	DRAWN BY R.B.G.

curr. James Cal Iles

DUVAL CORPORATION

J. M. G.

MAR 22 1971

MINING AT THE ESPERANZA PROPERTY

History

The old New Years Eve underground mine, the first workings in the Esperanza area, was operated spasmodically, mining copper, from 1895 until the present Esperanza open pit property was developed.

The area was first visited by Duval personnel in the fall of 1954. In May 1955, exploration drilling was started on a 500-foot equilateral, triangular grid pattern. By May 1957, 88 churn and diamond drill holes were completed for a total footage of 30,724 feet. In addition, 2,100 feet of underground workings were excavated to gather more information concerning the ore body.

Pre-mining stripping of waste was started in November 1957, with Isbell Construction Company performing the mining under contract. By February 1959, when the mill was completed, sufficient ore was exposed to start actual production from the Esperanza Mine.

Exploratory drilling discovered ore in an adjacent area called West Esperanza in July 1960. Exploration and development drilling of this area, during 1961 and 1962, consisted of 141 rotary and diamond drill holes for a total footage of 26,139 feet. In March 1963, pre-mining stripping was started with the first ore being produced from the West Esperanza pit in August 1965.

In July 1965, Duval purchased the mining equipment at Esperanza from Isbell and took over the mining operations.

Pit Dimensions

Esperanza Pit: the highest original elevation along the west side of the pit was 4,314 feet. The lowest elevation to be mined will be 3,515 feet

for an elevation difference of 799 feet. Six benches, each 35 feet high, are presently being mined. The maximum dimensions of the pit are 4,000 feet east-west and 2,500 feet north-south.

West Esperanza Pit: the highest original elevation was 4,422 feet. The lowest elevation will be 3,800 feet for an elevation difference of 622 feet. Three benches, each 50 feet high, are presently being mined. The maximum dimensions of the pit are 2,100 feet east-west and 3,800 feet north-south.

Rock Types

The ore bodies are of the porphyry type with the main ore-bearing rocks being quartz-monzonite porphyry, quartz diorite, and andesite porphyry. Other types of rocks encountered are quartzite, welded tuff, quartz latite porphyry and dacite. The rocks are of Cretaceous and Tertiary age. The main copper minerals are chalcopyrite and chalcocite. Molybdenum mineralization occurs as molybdenite.

Blasting and Mining

In blasting the rock, 9-inch diameter holes are drilled with a rotary drill. These holes are approximately 20 feet apart and are drilled to a depth of 7 feet below the next lower bench. The holes, when dry, are loaded with ammonium nitrate mixed with diesel fuel and blasted. When the blast holes contain water, a gelatin type of blasting agent called slurry is used.

In order to determine whether the material to be mined is ore, leach, or waste, a sample is taken of the cuttings of each blast hole and assayed. The results determine whether the blasted material is to be designated as ore, leach, or waste. Material is considered ore if it contains copper and molybdenum equivalent to 0.40% copper or above. All material with a copper equivalent content between 0.15% and 0.40% is considered leach. Any material

containing less than 0.15% copper equivalent is designated as waste.

Mined Tonnage

The total tonnage mined from the Esperanza and West Esperanza pits as of July 1, 1968 was 116.5 million tons. This represents 43.0 million tons of waste, 33.5 million tons of leach and 40.0 million tons of ore containing less than 1% copper. At present, approximately 280,000 tons of material are mined per week.

Equipment

Electrically powered shovels are used for loading the blasted rock. Shovels range from five to 12 cubic yard capacity. The capacity refers to the size of the bucket on the shovel. Haulage trucks vary from 35 to 75 ton capacity. The mine operates 3 shifts per day, 7 days per week during which period 35 shovel shifts are worked. The majority of ore is hauled on the second and third shifts which enables maintenance work to be done on both the crushing and mining equipment on day shift.

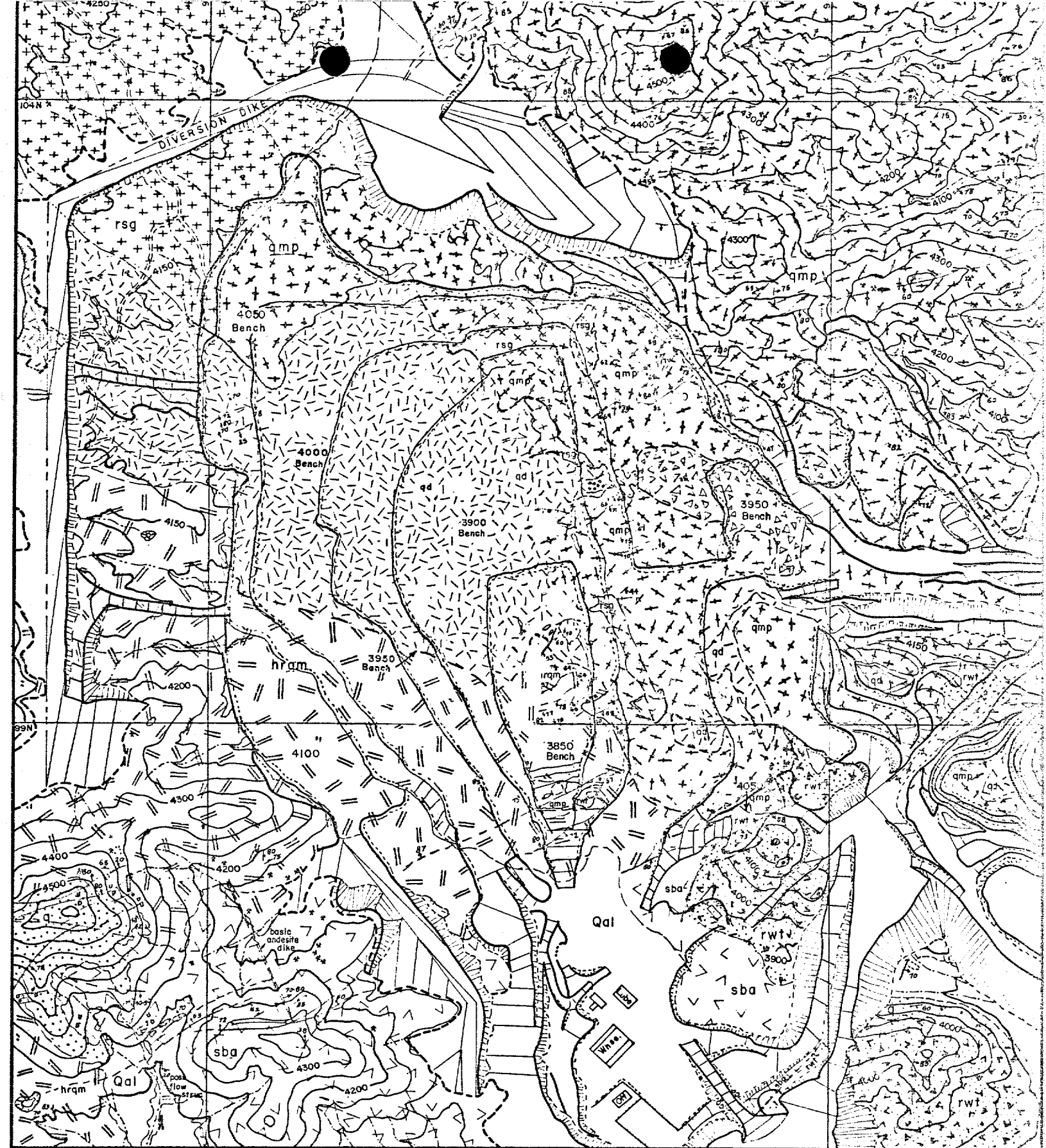
Leach Dumps

Leach dumps are located between hills and over arroyos in order that the return water from the dumps can be collected. Leach solution, containing some acid, is sprayed on the surface of the dump. As the solution percolates down through the dump it dissolves the copper from the rock. The pregnant or copper-bearing solution is then collected below the dump and piped to the precipitation plant. Here the copper is removed from the pregnant solution by flowing it through beds of shredded iron scrap. The copper precipitates out in the form of a mud called cement copper or precipitate copper containing approximately 75% to 85% metallic copper.

The Mill

The mined ore is passed through three crushing stages during which it is reduced to less than one inch in size. It is then conveyed to the mill

which, on an operating basis of 24 hours per day, 7 days per week, has a daily milling capacity of 15,000 tons. Here it is passed through rod and ball mills in which it is ground to a very fine, almost powder, size. It then goes through the flotation sections where the copper and molybdenum are separated from the ore pulp. Further processing through flotation separates the copper from the molybdenum. The copper concentrate, containing approximately 25% copper, is shipped to smelters. The molybdenum concentrate, containing approximately 58% molybdenum, is further refined and shipped direct to the consumer.



EXPLANATION

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- Massive quartz veins
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- qd — Biotite quartz diorite
- hrqm — Harris Ranch quartz monzonite
- rwt — Oxframe rhyolite welded tuff
- q — Quartzite

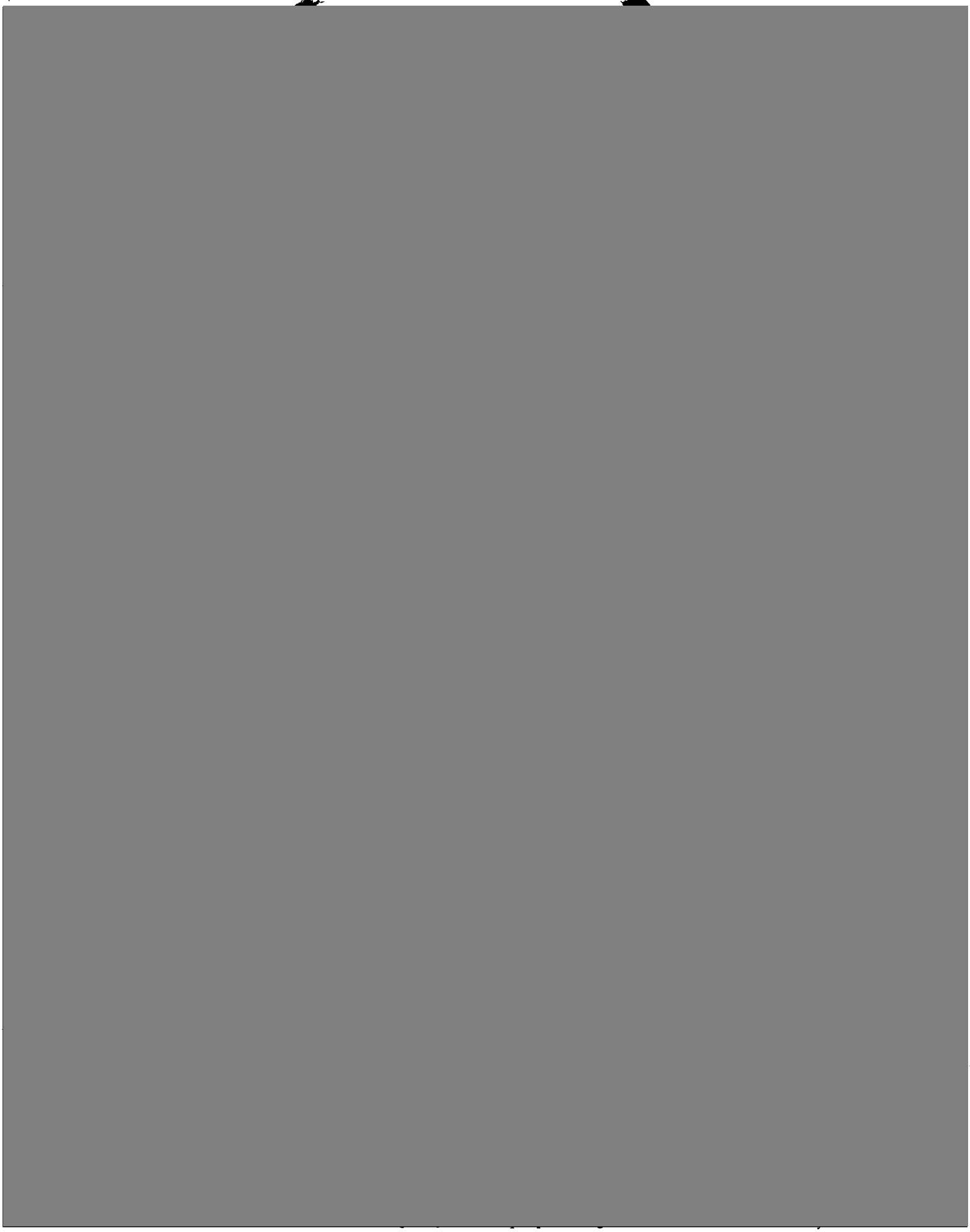
14

DUVAL SIERRITA CORPORATION

SIERRITA PIT GEOLOGY

SCALE: 1" = 1,000'	DATE: 12-1-70
GEOLOGY BY RAM, AHJ, BLW, DWL, FWM.	DRAWN BY R.B.G.

To: Mr. J. H. Courtright



June 14, 1968

To the Shareholders:

The attached press release should be of interest to you as a Duval shareholder.

WILLARD M. OWEN
Secretary

J.H.C.
JUN 18 1968

Duval Corporation
1906 First City National Bank Building
Houston, Texas 77002
Phone: 713-223-4481

JHC file : Duval Corp

For Release After 4:30 p.m. central daylight time

Houston, June 10 - W. P. Morris, president of Duval Corporation, a 76% owned subsidiary of Pennzoil United, Inc., headquartered here, commented today on the results of additional drilling in Culberson County, Texas, where Duval had announced on May 10, 1968, it was evaluating deposits of elemental sulphur.

Through June 6, 1968 Duval had drilled 33 test holes on a grid pattern with hole spacing of 1,000 ft. within an area which Duval believes will encompass the bulk of the sulphur deposition. Such drilled area embraces approximately 600 surface acres in the central and western part of section 10, and in contiguous portions of sections 3, 9 and 15, Block 111, PSL Survey. At that date there had been substantial to full recovery of formation samples from each of the holes. An analysis of such samples and of those from preliminary exploratory drilling has disclosed sulphur mineralization at varying depths ranging from 240 to 1,237 ft. below the surface. The vertical thickness of the mineralized formation varied in individual holes from the equivalent of two to 80 ft. of solid sulphur (except for a stepout hole which showed no sulphur mineralization). The arithmetic average of the thickness of the sulphur mineralization found in these individual holes was the equivalent of approximately 34 ft. of solid sulphur. The sulphur content in the various drill hole sulphur intercepts averages approximately 18%. In view of the incomplete geological information on hand and the apparent unusual character of

(more)

the sulphur deposition, Duval does not consider the drill and other data sufficient to make a representation at this time as to the tonnage of sulphur in place.

Duval plans to drill approximately 60 additional test holes on the grid pattern as a further step in determining the extent and feasibility of mining the deposit. Most of such drilling will be conducted in sections 2, 3, 4, 9, 15 and 16 contiguous to the area of principal interest in section 10. Duval will also consider whether it will be advisable to drill additional test holes within the 600 acre tract described above.

To the best of Duval's present knowledge, sulphur found under the conditions and at the depths encountered by Duval in Culberson County could be mined commercially only by the Frasch process. Historically, the Frasch process has been confined to the recovery of sulphur found in salt dome structures along the Gulf Coast of Texas and Louisiana and in Mexico. The application of the process to other types of structures found in far West Texas, such as Duval's Ft. Stockton property and the Culberson County location where a salt dome is not present, is a relatively new and untried development. In order to obtain data on the mineability of the sulphur deposition by this method, a Frasch pilot plant is being erected in section 10 at this time. Initial operation of this plant is scheduled for mid-June, 1968.

This substantial amount of additional testing and evaluation will be necessary before Duval can decide, not only the full extent and continuity of the deposition, but whether it can be mined on a commercial basis by the Frasch process. Until this work is completed, Duval can give no assurance as to whether it has a mineable sulphur deposit at the Culberson County property or what the economic significance, if any, of such deposit may be.

Harold---

This paper on Mineral Park was given as a talk somewhere--maybe the recent AIME meeting in New York?
If you do not have a copy and would like one, let me know and I'll send mine along for office copying.

BNW

AMERICAN SMELTING AND REFINING CO.

Orange, California

May 24, 1968

J. H. C

JUN 4 1968

Dean W. Lynch
c/o Duval Corporation
4715 E. Fort Lowell Rd.
Tucson, Arizona 85716

Dear Dean:

Muchas gracias for sending along the copy of Donn Clippinger's paper entitled "A Case History of Copper and Molybdenum Geochemical Prospecting at the Mineral Park Mine of Duval Corporation."

Donn's findings corroborate the results of similar geochem surveys on other Arizona porphyry coppers, including our work at Silver Bell. Our work was done, however, about 5 years after the Mineral Park study.

Saludos,

BNW

Barry N. Watson

Duval Begins Huge Digging Job

By JOHN RIDDICK
Citizen Staff Writer

The Duval Corp. has launched the opening phases in the building of the mill and the digging of the pit for its new $151 million Sierrita copper mine.

The company has given a contract for about $90 million to the Stearns - Roger Corp. of Denver to build the mill and associated facilities. And Duval itself is putting in roads and assemblying equipment to start opening the pit.

"We will be moving 190,000 tons of overburden a day by the first of May in full production on the pit," said George E. Atwood, Duval executive vice president.

The new Sierrita mine will adjoin Duval's Esperanza open pit copper mine about 30 miles south of Tucson and will be the largest mine in Arizona.

The company is on a short schedule since it plans to be in production within two years and must begin delivering copper to the government to repay an $83 million loan by the spring of 1970.

The Duval Corp. formed a subsidiary, the Duval Sierrita Corp., to sign a contract with the General Services Administration (GSA) and operate the new mine.

Under the complicated contract, GSA, besides putting up the $83 million, is largely guaranteeing a $48,750,000 private loan from banks. Duval, which already has spent $3.5 million ... will add another

ture of the ore body and the low earnings which we projected for the early years of the operation, the company didn't feel it could finance the opening of the mine without the assistance of the type given by the GSA," said Atwood.

Approximately 25 per cent of the Sierrita's copper during the first five and one-half years of production will go into the government stockpile to repay the $83 million loan.

After an extensive amount of drilling, Duval became convinced early in 1966 that it had a massive ore body.

It then approached the GSA under a new federal program to encourage new domestic copper production.

Up until now, Duval has drilled 87 holes delineating an estimated 414 million tons of ore along with 600 million tons of overburden and waste rock. The average depth of the holes is 1,000 feet.

This has led to a 20-year-projection of sales estimated at $1,442,188,000. The total includes $995,790,000 in copper calculated at 38 cents a pound; $432,111,000 in molybdenum, at $1.81 a pound; and $14,278,000 in silver, at $1.57 an ounce.

The Sierrita is remarkable among copper mines for its large amount of molybdenum, estimated at 30 per cent of its total wealth.

And the new Sierrita will put Duval among the nation's largest producers of molybdenum, ... fine steel, with

per cent of the free world's production.

Atwood said that with further drilling Duval expects to discover more copper to carry the mine on beyond the present 20-year projection.

W. P. Morris, Duval president, said that there will be no cash flow to the company during the phase when it is repaying its government loan but that the Sierrita would be beneficial to the company and its shareholders on a long-term basis.

Duval is spending $19 million on the equipment to strip the 105 million tons of overburden. This will include a fleet of forty 120-ton diesel electric wheel trucks.

Out of the 2,800 manpower force expected at the peak of the construction phase in 1969, about 400 will be working on the excavation of the pit.

Stearns-Roger, which has already begun grading for the mill site, will employ the others to build a huge mill nearly a quarter mile long. There are approximately 130 working now on the beginning stages of the mill and pit.

The mill will have a minimum capacity of 60,000 tons of ore a day, slightly larger than the 58,000-ton daily operation of the Phelps Dodge Corp. at Morenci.

The copper ore at the Sierrita mine is of low grade, presenting a challenge in technology. Duval earlier made innovations such as in automation in its success in taking a profit out of the Esperanza's "tough, low grade."

During the production phase when it finally settles down, the Sierrita will require a steady payroll of 1,100. The Esperanza will continue to operate as a junior partner next door with about 390 employes handling 15,000 tons of ore a day.

Duval has its corporate base in Houston but its production headquarters here at 4715 E. Ft. Lowell Rd. The company is owned 76 per cent by the United Gas Corp. which in turn is owned 42 per cent by the Pennzoil Corp.

Since 1950, Duval has had a growth from $5 million in assets to about $200 million today, headed towards perhaps $400 million in two years.

Among the responsibility of the staff in Tucson is bringing into production by mid-year an enormous $70 million potash operation in Saskatchewan, Canada. Duval started to acquire land for this project in the early 1950s.

"We hope for a bright future in potash," said Atwood, who is a specialist in that mineral vitally needed by agriculture.

Aside from the Esperanza, Duval now has in production in Arizona the Mineral Park copper operation near Kingman.

How has Duval accomplished such growth?

"We put together a good team of young, talented, able people interested in building and creating," said Atwood.

New York, N. Y. October 25, 1967

J. H. C.

FILE MEMORANDUM

NOV 1 1967

Mr. W. B. Wilkerson, Treasurer, Duval Corporation and J. Kirkland, Financial Vice President of Pennzoil, met with J. G. Cox and myself in regard to Duval's most recent delay in concluding their contract on Sierrita with the GSA.

The project itself is to be financed - $83 M GSA funds, $49 M private capital and $16 M from Duval, for a total of approximately $148 M. The $49 M has been arranged for and the GSA was to put up the $83 M as advance purchase of copper and this was to cover the first $83 M spent on the development of mine and mill.

Due to the austerity program in Washington, the GSA was ordered to delay transfer of funds into the project until beginning Fiscal 1969 and to delay the last $25 M until Fiscal 1970. New financing arrangements were therefore required.

Without going into the complicated details of the Duval financing, Duval requires a put of $25 M during Fiscal 1969 to back up short term commercial paper in the event the holders of the paper want an out prior to the GSA pay off in July, 1969. The put may never be used, but is necessary to float the loan which must be done to complete finance arrangements and to conform to GSA requirements a signed contract.

Duval is in the process of arranging the $25 M put with various banks around the country. Messrs. Wilkerson and Kirkland figure this will require 2-3 weeks. They discussed the possibility of ASARCO accepting the put in order to expedite the GSA contract with Mr. Hamrick, but this was declined.

We felt the prime purpose of their visit was to show that they are not dragging their feet in concluding the contract with GSA and assured us that the contract would be successfully closed in 2-3 weeks at the outside. They are aware of our pressures and did not want us to jerk the rug out from under them in the interim period. We advised them that time was of the essence, that we were dealing with a substantial portion of our smelting capacity in negotiations which must be successfully supplied, but respected their assurance of concluding the GSA deal. They will keep R. Welch advised currently of how things are going in this respect.

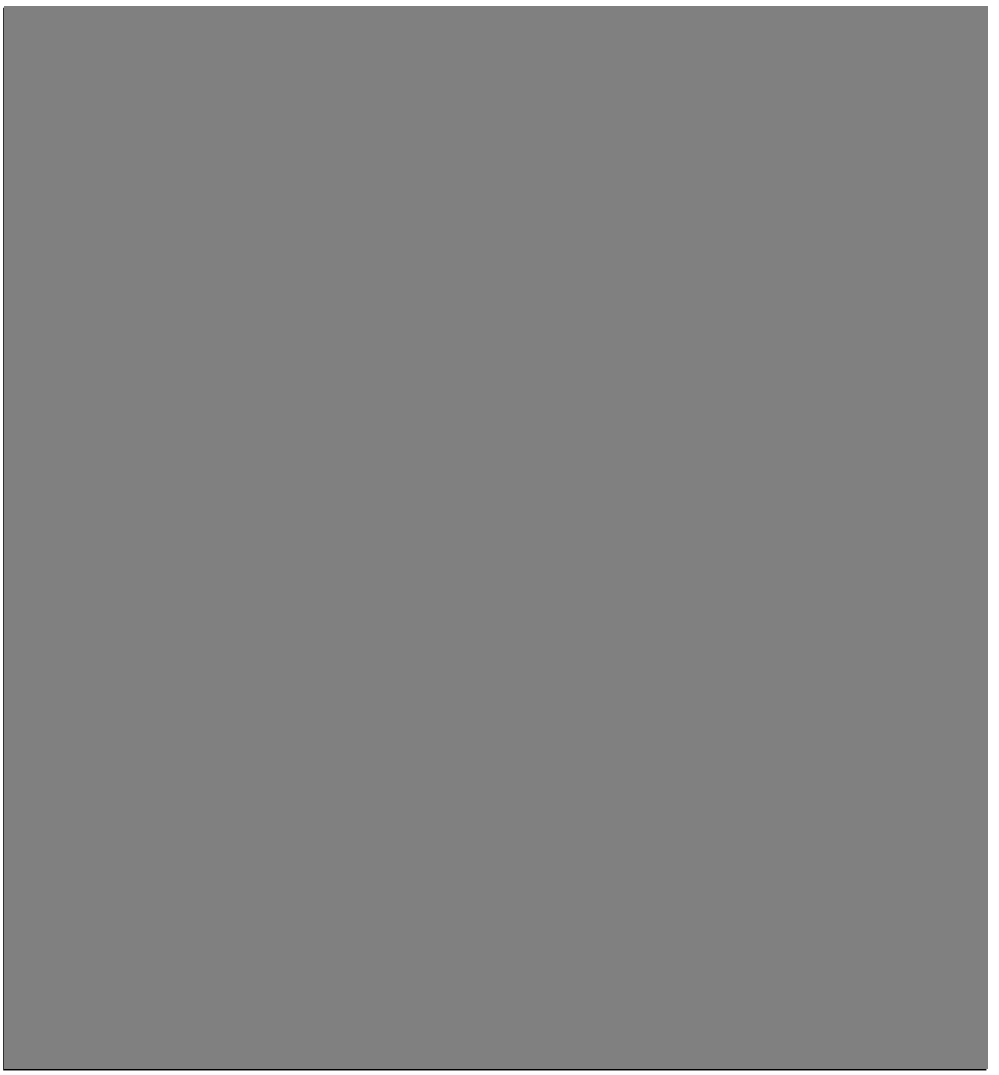
As an aside, they said they had $10,000,000 worth of equipment on site or on order to start mining, which was evidence of their confidence that the project will go forward.

R. M. McGeorge

RMM:ks

cc: RLHennebach
ALHatch
K.D.Loughridge
R°F°Welch

RECEIVED
NOV 1 1967
REED F. WELCH



4a-16.20.5c

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

J. H. C.

January 5, 1967

MR. W.E.S.
READ AND RETURN
JAN 5 1967
PREPARE ANSWERS ___ HANDLE ___
FILE ✓ INITIALS
W.E.S.
FEB 14 1967

To: J. H. Courtright

From: S. I. Bowditch

Exploration Potential Northeast
of Beach Mining Property
Pima Mining District
Pima County, Arizona

I refer to Mr. Kinnison's memorandum to you of Dec. 28,1966, above caption (except he had the first two lines reversed). In accordance with the suggestion contained in the third paragraph of his memorandum, I have investigated the ownership of the area, particularly section 13, in which the greater part of the mineralized area is thought to occur.

Section 13, T18S, R12E, is State Land. Duval has commercial lease C-343N covering all this section. At one time Duval had a mineral lease here as well, but canceled it after the commercial lease was issued, in 1957. The greater part of the area of interest is covered by the Duval tailings pond. In order to obtain its commercial lease Duval had to prove to the State's satisfaction that the ground was unmineralized. Harry Fieldman had a prospecting permit on this section in 1964, but this was canceled by the commissioner.

Incidentally, I was told that formerly the State required drilling to a depth of only a few hundred feet to prove lack of mineral, but that just recently, as a result of Anaconda's deep ore, the State now requires that holes go to 2000 feet.

Section 14, to the north of the Beach property, is also covered by Duval's commercial lease, and also by a prospecting permit issued to Clare F. Filatrout, et al, (pals of Fieldman?) dated April 4, 1964.

In Section 12, the north 3/4 is pretty well covered by patented mining claims, now owned, I believe, by Banner. The SW 1/4 SW 1/4 belongs to Duval, which owns surface and mineral rights. The SE 1/4 SW 1/4 and S 1/2 SE 1/4 is owned by the Boyd Land and Cattle Company (Anaconda) but mineral rights belong to the Federal government.

The Boyd Land and Cattle Company also owns the surface of Section 7 of T18S, R13E, and the mineral belongs to the Federal government.

Section 18, T18S, R13E, is also State Land. Duval has a commercial lease on at least part of the surface, but I seem to have neglected to note the exact area. Prospecting permits have been issued and reissued for odd parts of the section, chiefly to Woolsey and his pals. At present a prospecting permit for one odd shaped part is held by R. L. Stanton, who slipped in between two Woolsey refilings, and a permit for another piece is held by one Paul Zaches.

In summary, Section 13 covers the most interesting area, and is open for an application for a prospecting permit, but as most of the area of interest is now under Duval's tailings pond, any work would immediately involve a dispute with Duval, and any mining would require moving the tailings to some other location.

S. I. Bowditch

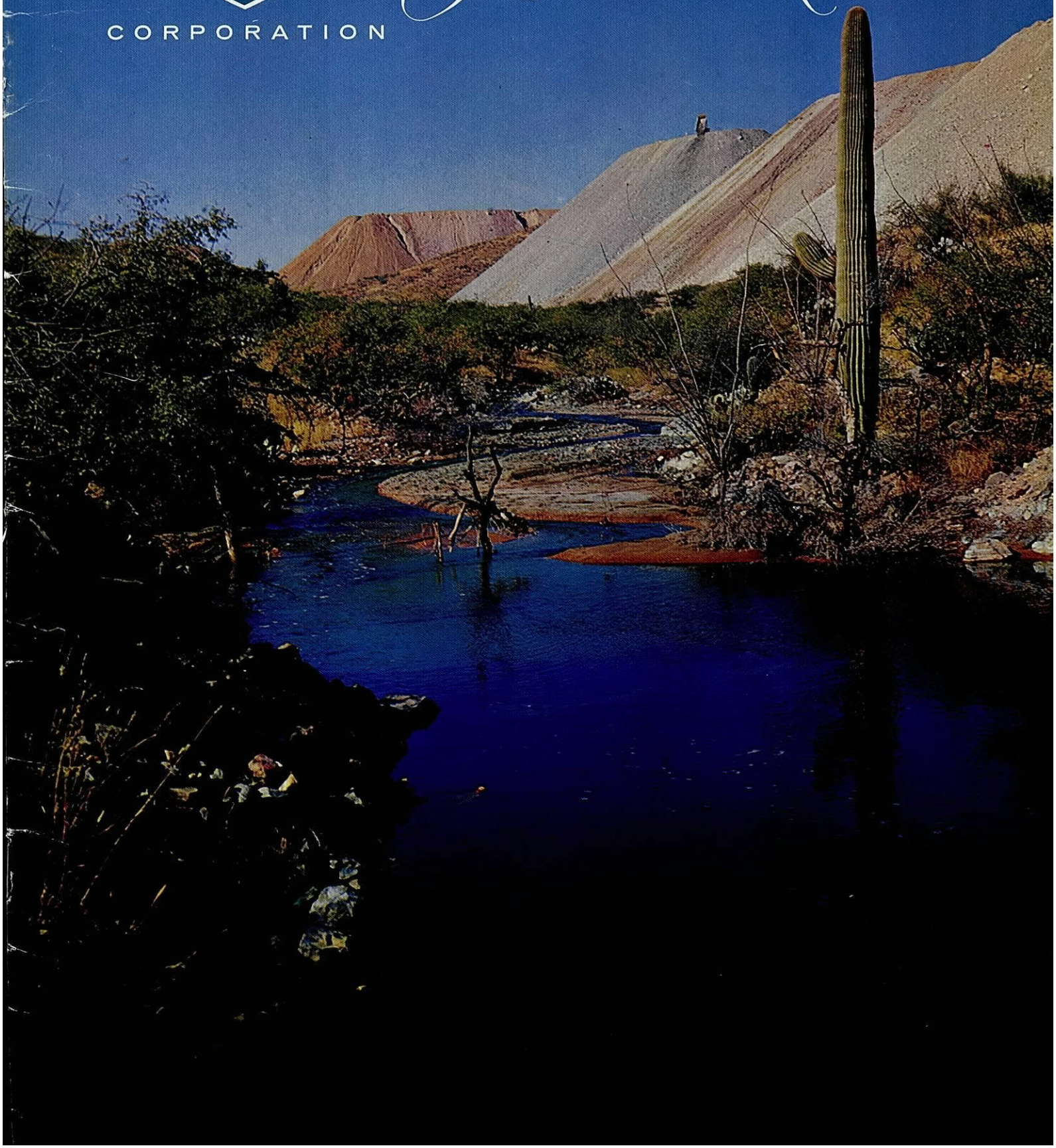
S. I. Bowditch

SIB:bam
cc: JEKinnison

DUVAL CORPORATION

1963

Annual Report



ON THE COVER *Copper bearing solution flowing from Esperanza leach dumps in background toward copper precipitation plant.*

ANNUAL MEETING

The Annual Meeting of Shareholders is scheduled to be held in Houston, Texas at 10 A.M. on Tuesday, March 17, 1964. Proxy statements will be mailed to shareholders on or about February 19, 1964. **Shareholders who cannot be present at the Annual Meeting are urged to vote by proxy.**

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DUVAL CORPORATION

1963 *Annual Report*

REGISTRAR

THE CHASE MANHATTAN BANK
New York, New York 10015

TRANSFER AGENT & DIVIDEND PAYING AGENT

MANUFACTURERS HANOVER TRUST COMPANY
New York, New York 10015

Financial and Operating Highlights

	1963	1962
Gross Revenues	**$26,236,775**	$27,325,606
Net Earnings	**$ 4,363,872**	$ 4,462,751
Earnings Per Share	**$ 3.36**	$ 3.43
Dividends Paid		
Total	**$ 1,820,000**	$ 1,819,996
Per Share	**$ 1.40**	$ 1.40
Earnings Retained in the Business		
Total	**$ 2,543,872**	$ 2,642,755
Per Share	**$ 1.96**	$ 2.03
Total Assets	**$58,188,131**	$42,515,283
Shareholders' Equity	**$39,841,645**	$37,297,773
Working Capital	**$11,988,238**	$10,664,901
Ratio of Current Assets to Current Liabilities	**5.0 to 1**	3.3 to 1
Capital Expenditures	**$18,546,636**	$ 2,801,596
Number of Shareholders	**1,668**	1,791
Shares Outstanding	**1,300,000**	1,300,000
Production:		
Sulphur — Long Tons	**174,000**	191,625
Potash — Short Tons	**495,588**	434,925
Copper — Pounds	**46,785,955**	45,948,672
Molybdenum — Pounds	**1,139,886**	1,248,023
Silver — Ounces	**137,716**	158,610

DUVAL

CORPORATION

To the Shareholders:

Gross revenues in 1963 were $26.2 million compared with $27.3 million in 1962. Revenues from the Copper Division were in balance with last year, a slight increase in copper sales being offset by a decrease in molybdenum sales. Potash revenues were down slightly due to a small reduction in the tonnage sold. Sulphur revenues were down substantially due to an overall reduction in sales volume and a lower price realization in the foreign market.

Net earnings were $4.4 million, down $0.1 million from 1962. Earnings per share were $3.36 compared with $3.43 in 1962.

Dividends declared and paid in 1963 remained unchanged from 1962 at $1.40 per share.

Potash production increased 14 percent in 1963, the increase reflecting a combination of high production in 1963 and low production in 1962, the year in which the industry experienced an extended work stoppage. Copper production was up slightly as an increase in production from leach-precipitation operations more than offset a decrease in production from milling operations. Sulphur and molybdenum production were down moderately in 1963.

Development and construction work on the Mineral Park copper-molybdenum property near Kingman, Arizona and the Nash Draw langbeinite property near Carlsbad, New Mexico was begun in late 1962. Production operations at both properties are expected to commence in the latter part of 1964.

The Mineral Park and Nash Draw projects were financed in 1963 by the sale of debentures and the establishment of a line of bank credit.

The cost of mine development work at Nash Draw, Mineral Park and West Esperanza as well as interest costs on borrowed funds during the period of development and construction at Nash Draw and Mineral Park are being capitalized for accounting purposes. For Federal income tax purposes, however, such costs are being treated as deductions from taxable income. The estimated resultant tax reduction is being credited to deferred Federal income tax liability to be amortized ratably over the operating lives of the properties. In 1963, the amount deferred was $2,275,510. In 1962, a similar tax reduction of $144,990 was credited to income tax expense.

The Company's exploration group was engaged principally during the year in extensive geological and geophysical work on four properties, mineral rights to which are either owned by or under option to the Company. In addition, the group conducted numerous geological investigations of mineral prospects in the West and Southwest.

The research and development group devoted its attention to the refinement of plant processes and ore treatment techniques. This group also assisted in the engineering design of the Nash Draw and Mineral Park plants.

At the Annual Meeting of Shareholders held on March 19, 1963, at Houston, Texas, the name of the Company was changed to Duval Corporation and the authorized Capital Stock was increased to 3,000,000 shares from 2,000,000 shares.

The Board of Directors acknowledges and expresses its appreciation for the continuing efforts of the Company's employees who have been in such a large measure responsible for the Company's growth.

Respectfully submitted,
On Behalf of the Board of Directors
W. P. MORRIS, President

January 20, 1964

Sulphur loading operations at Galveston, Texas.

SULPHUR DIVISION

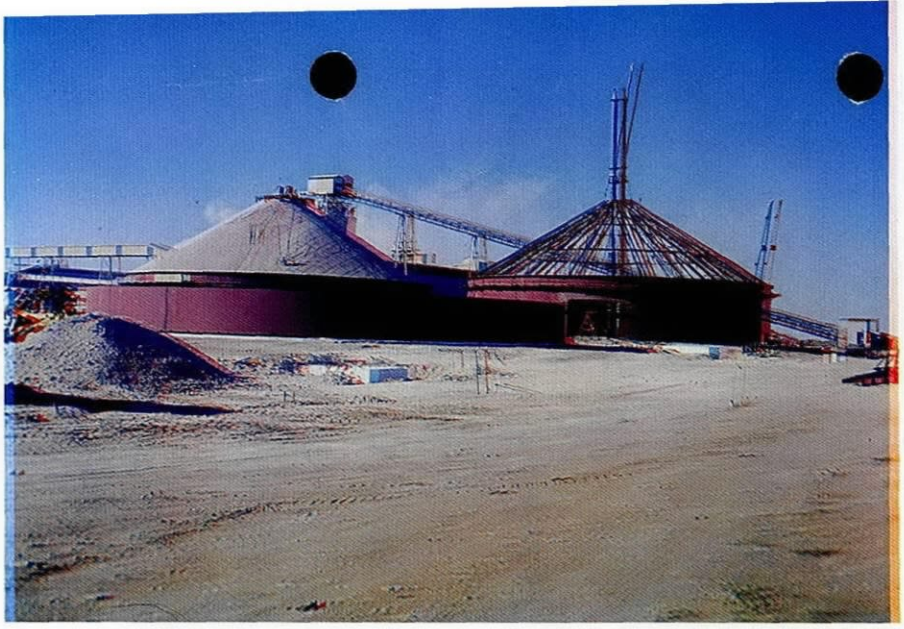
Production operations at the Company's Orchard Dome sulphur property in Fort Bend County, Texas continued through 1963 on an efficient and economical basis. Except for a period of approximately two months in the first quarter, during which time hot water input in one area of the mine was curtailed to permit the reworking of several production wells, operations were conducted at plant capacity levels. Production in 1963 of 174,000 long tons, while 17,625 tons less than the abnormally high production of 191,625 tons in 1962, was in balance with average annual production in the preceding five year period. The per ton cost of sulphur produced, while up significantly from 1962, was below average cost during the preceding five years.

Sulphur sales volume in 1963 was down 11 percent from 1962 with essentially all of the reduction occurring in the domestic market. Prices received for sulphur sold in the domestic market were in balance with last year, but prices received for foreign sales dropped 18 percent. In the main, pressure on prices in the foreign market developed from efforts of producers in Mexico, Canada and France to dispose of their production in a market in which supply exceeded demand. As a result of the combined effects of lower volume in the domestic market and lower prices in the export market, Sulphur Division earnings were down significantly.

Sulphur consumption in this country and abroad continues to show an encouraging annual growth rate, but it is difficult to determine when the present imbalance between supply and demand will be corrected and sulphur prices will return to more realistic levels.

POTASH DIVISION

Operations at the Company's Carlsbad potash properties were normal throughout the year. Production of 495,588 short tons was up 60,663 tons from 1962. Approximately one-third of this increase was attributable to a high rate of



Potassium sulphate product warehouses under construction at Carlsbad, New Mexico.

production in 1963 while the remainder resulted from reduced production in 1962 due to a sixty day industry-wide work stoppage. Costs per ton of product were substantially unchanged from 1962.

Sales volume of the Company's own production of potash was down approximately three percent from last year. This decline in sales stems primarily from a low inventory position at the beginning of the heavy shipping season in the early part of the year, a delayed effect of loss of production in 1962. Additionally, in an effort to re-establish a satisfactory inventory position, the Company virtually withdrew from the foreign market during the second half of the year.

Prices in the domestic market were essentially unchanged from the preceding year and demand was excellent. Prices in the foreign market softened during the year as increased quantities of North American production became available to the market.

The development of the Nash Draw langbeinite ore body and construction of facilities to process the ore to be produced therefrom are in progress. Development work at the mine site located 13 miles south of the Company's original mine and mill includes the sinking of two circular shafts. The langbeinite ore body will be placed in production in the latter part of 1964.

The langbeinite ore will be transported by rail to processing facilities now being constructed adjacent to the existing mill. In one section of the new plant the ore will be crushed and washed to produce washed langbeinite, known to the fertilizer trade as sulphate of potash-magnesia. A portion of this product will be marketed as a plant nutrient while the remainder will be further processed to produce potassium sulphate. Storage, loading and shipping facilities for each of the two products are now under construction. The designed initial annual capacity of the new plant will be 90,000 tons of sulphate of potash-magnesia and 75,000 tons of potassium sulphate. The plant is designed in such manner that productive capacity can be increased readily if additional production is needed to meet future market requirements.

Nash Draw ore hoisting shaft location showing refrigerant manifolds and freeze well locations prior to commencement of sinking operations.

The Company is presently installing equipment required to increase the particle size of muriate of potash now being produced. When this installation is completed and the langbeinite processing facilities are placed in operation, the Company will be in a position to offer a broad range of high quality potash and potash-magnesia products in the most desirable particle sizes.

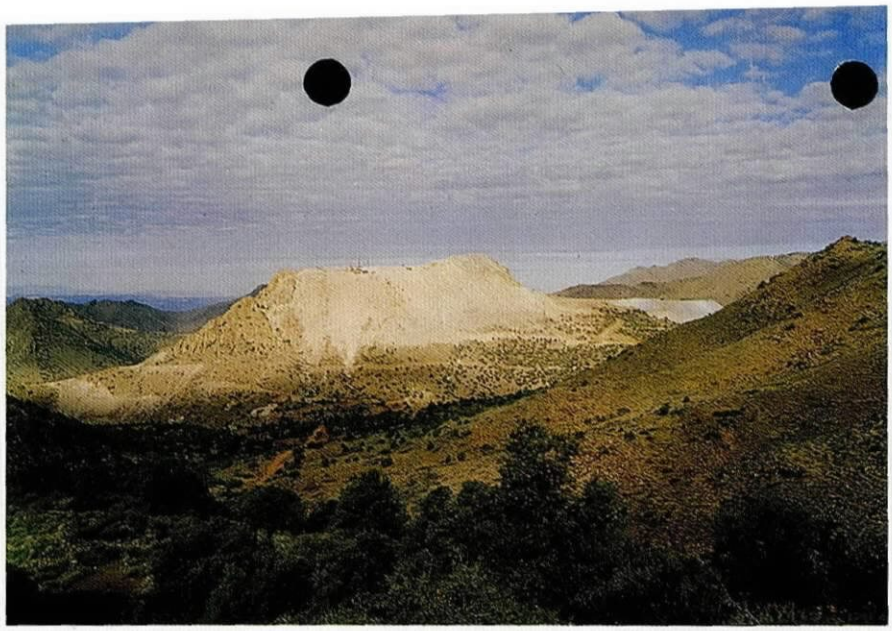
COPPER DIVISION

Production of copper at the Esperanza property near Tucson, Arizona was 46,785,955 pounds, up 837,283 pounds from 1962. An anticipated slight decrease in the grade of the ore milled resulted in a reduction in copper produced by milling operations, but this reduction was more than offset by an increase in production from leach-precipitation operations. Molybdenum production of 1,139,886 pounds was 108,137 pounds under 1962. This decrease also stemmed from a reduction in the mineral content of the mill feed. The milling rate increased from an average of 11,315 tons per day in 1962 to 11,568 tons in 1963. Unit costs and total production costs compared favorably with 1962.

Copper and molybdenum sales volume kept pace with production in 1963. The custom smelter copper price has remained unchanged since May 1961 at 31¢ per pound, less applicable smelting, refining and transportation costs. Average realization per pound of molybdenum sold was in balance with last year. Demand for both metals was good.

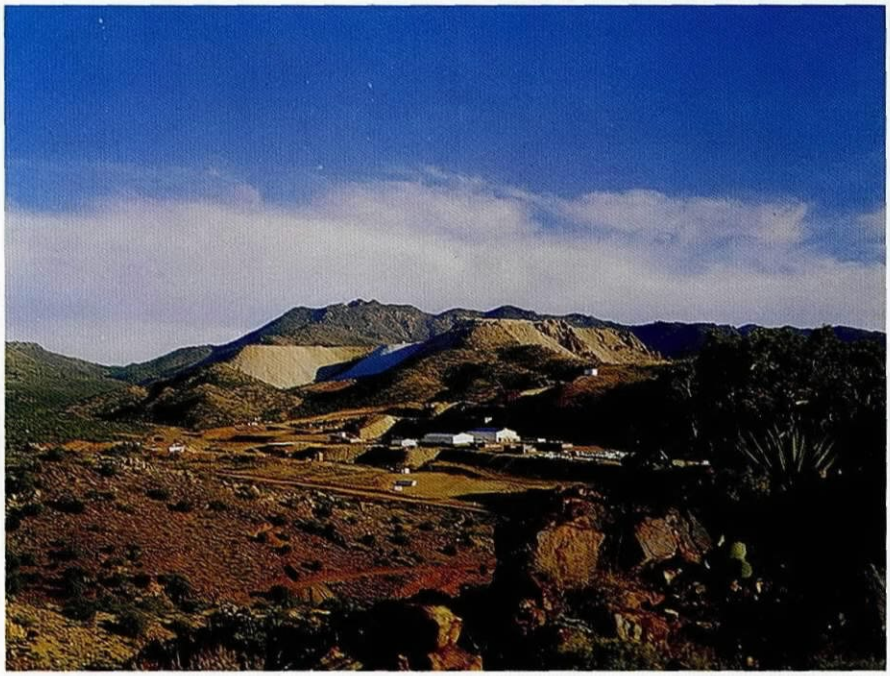
The removal of waste capping overlying a satellite copper-molybdenum ore body situated immediately west of the main Esperanza pit was begun in March 1963 and is expected to be completed during 1965. Total capping expected to be removed in the three years is six million tons. Upon completion of the pre-mining stripping, ore from this deposit, known as the West Esperanza ore body, will be mined and milled concurrently with ore from the main pit.

The development of the Mineral Park copper-molybdenum ore body near Kingman, Arizona and the construction of milling and auxiliary facilities are well

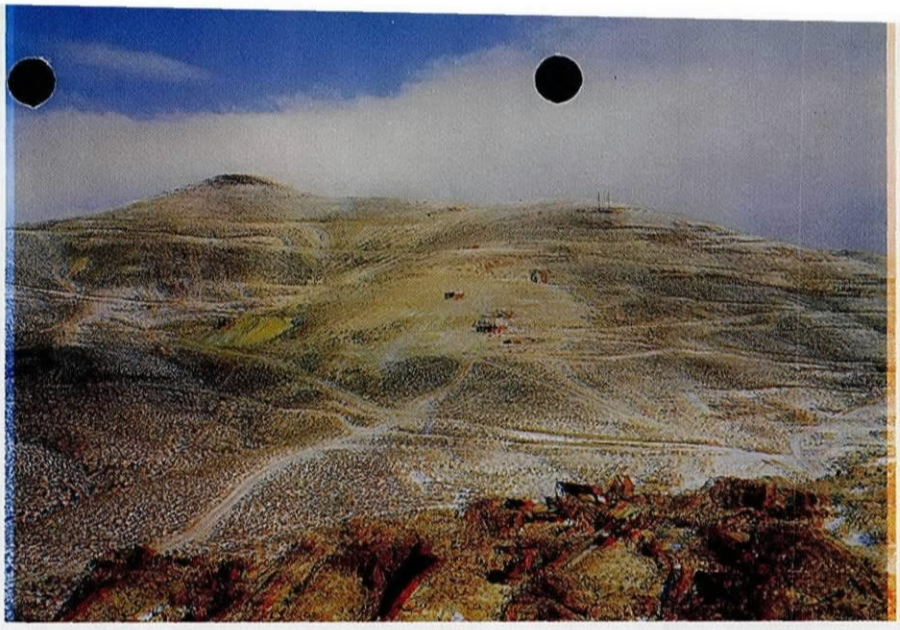


Ithaca Peak at Mineral Park showing waste overburden removal in progress.

advanced. Approximately 50 percent of the 18 million tons of waste overburden which must be removed prior to commencement of production operations had been removed at year end. Office, warehouse and shop facilities are either completed or nearing completion. Foundations for crushers and mill buildings have been poured and the erection of structural steel is in progress. The water field has been developed and a 14 mile pipeline from the water field to the mill site has been completed. Present equipment delivery schedules will permit completion of the project and commencement of production operations late in the third quarter of 1964. The Mineral Park plant will have a designed ore milling capacity of 12,000 tons per day which will make it comparable in size to the Esperanza plant.



Plant construction and pre-mining stripping at Mineral Park copper-molybdenum property at year end.



Site of Company's exploration activities in the Battle Mountain District of northern Nevada showing drill roads, drilling equipment and old mine workings.

EXPLORATION

Additional personnel were employed in the exploration group in 1963 to provide adequate staffing for a continually expanding program, the objectives of which are to increase reserves of minerals now being produced and to locate and appraise reserves of other minerals.

An extensive geological investigation and an exploratory drilling program on a mineral property in the Battle Mountain mining district in northern Nevada have been in progress since the latter part of 1962. This work, expected to continue through the first half of 1964, is for the purpose of evaluating the commercial possibilities of mineral production from this district.

Other activities of the exploration group included studies to determine the extent of mineralization in areas adjacent to Esperanza and Mineral Park and of numerous other mineral prospects in the West and Southwest. A district geological office is being established in Vancouver, British Columbia to provide direct coverage of mineral developments in the northwestern part of the United States and in western Canada.

RESEARCH AND DEVELOPMENT

The primary effort of the research and development group in 1963 was directed toward the refining of the processes selected for production of potassium sulphate products from the Nash Draw langbeinite ore and for the treatment of the Mineral Park copper-molybdenum ore. Additionally, personnel from this group collaborated with the engineers of the prime contractors in the design of the facilities now being constructed at Mineral Park and Nash Draw.

The potash solution mining pilot plant in Saskatchewan was in continuous operation in 1963. Operating conditions were changed periodically to develop field test data on the variables associated with this type of mining. Further experiments are scheduled to test the effects of solution temperatures and recirculation rates on the production of potassium brines under pilot scale conditions.

Numerous other studies are underway in the research laboratories. These investigations deal with new processes and new products in a program planned to broaden the Company's activities in the mining, processing and industrial chemicals fields.

PERSONNEL

There were 797 Duval employees at year end, an increase of 22 over 1962. Additional personnel were required in connection with the development of the Mineral Park property and expanded activities in the exploration and research and development groups. The number of operating personnel was essentially unchanged from last year.

Direct salary and wage payments to employees in 1963 were $5,662,227. In addition, the Company paid on behalf of its employees $368,754 as its part of the cost of employee retirement, group life insurance, group health and medical care plans.

FINANCE

Funds required for financing the Nash Draw and Mineral Park projects are being provided from cash generation, proceeds from the sale of convertible subordinated debentures and from bank loans. The debentures, bearing interest of 4⅝% and having a final maturity date in 1983, were sold in August at the face value of $10,000,000. A credit agreement which provides a line of credit of $25,000,000 was negotiated with three commercial banks. At year end, $3,000,000 had been borrowed.

SOURCES FROM WHICH FUNDS CAME

Net income	$ 4,363,872
Depreciation and depletion	2,202,878
Proceeds from sale of debentures	10,000,000
Proceeds from bank loans — current financing	3,000,000
Proceeds from short term loan	2,000,000
Decrease in current maturities of previous bank loan	1,387,500
Deferred Federal income tax	2,347,150
Other	274,606
Total	25,576,006

USES TO WHICH FUNDS WERE APPLIED

Construction, development, acquisition and replacement of properties	$18,546,636	
Less net salvage from retirements	51,467	18,495,169
Repayment of previous bank loan		1,937,500
Repayment of short term loan		2,000,000
Dividends		1,820,000
Total		24,252,669
Increase in working capital		1,323,337
Working capital — December 31, 1962		10,664,901
Working capital — December 31, 1963		$11,988,238

DUVAL
CORPORATION

Sources and Uses of Funds

DUVAL

CORPORATION

BALANCE SHEET,

Assets

	1963	1962
CURRENT ASSETS:		
Cash	$ 5,543,070	$ 7,128,616
Working funds	38,000	33,000
Accounts receivable:		
Customers (less reserve for doubtful receivables)	3,154,389	3,209,957
Refundable Federal income tax (Note 1)	729,805	
Other	194,576	209,891
Inventories:		
Products (at cost — less than market)	3,760,627	3,060,077
Materials and supplies (at average cost)	1,430,715	1,549,220
Prepayments	47,276	51,916
Other	76,116	76,734
Total current assets	14,974,574	15,319,411
PLANT, EQUIPMENT AND LEASES — At cost (Note 2)	62,254,450	43,963,036
Less reserves for depreciation and depletion	19,304,731	16,934,441
Plant, equipment and leases — net	42,949,719	27,028,595
DEFERRED CHARGES:		
Unamortized debt expense	124,736	
Advance royalties	67,066	75,190
Public utility deposit	26,783	48,902
Other	45,253	43,185
Total deferred charges	263,838	167,277
TOTAL	$58,188,131	$42,515,283

The accompanying Notes to Financial Statements are an integral part of this statement.

December 31, 1963 and 1962

Liabilities

	1963	1962
CURRENT LIABILITIES:		
Current maturities of bank loan		$ 1,387,500
Accounts payable	$ 1,243,356	948,015
Salaries and wages payable	203,660	180,119
Accrued liabilities:		
Taxes	927,749	1,764,129
Royalties	324,563	292,589
Interest	190,349	
Other	96,659	82,158
Total current liabilities	2,986,336	4,654,510
LONG-TERM DEBT:		
Bank loans — portion maturing after one year (Note 3)	3,000,000	550,000
4⅝% Convertible Subordinated Debentures Due 1983 (Note 4)	10,000,000	
Total long-term debt	13,000,000	550,000
DEFERRED FEDERAL INCOME TAX:		
Mine development and interest costs during construction (Note 1)	2,275,510	
Investment tax credit	84,640	13,000
Total deferred Federal income tax	2,360,150	13,000
CAPITAL STOCK AND RETAINED EARNINGS:		
Capital stock (authorized 3,000,000 shares of no par value; issued and outstanding 1,300,000 shares) (Note 4)	16,906,250	16,906,250
Retained earnings (Note 3)	22,935,395	20,391,523
Total capital stock and retained earnings	39,841,645	37,297,773
TOTAL	$58,188,131	$42,515,283

The accompanying Notes to Financial Statements are an integral part of this statement.

DUVAL
CORPORATION

Statement of Income and Retained Earnings

For the Years Ended December 31, 1963 and 1962

	1963	1962
REVENUES:		
Sales, less freight, allowances, etc.	**$25,935,298**	$27,055,410
Other	**301,477**	270,196
Total	**26,236,775**	27,325,606
COSTS AND EXPENSES:		
Cost of products sold (other than items below), loading and shipping expenses	**14,176,709**	15,023,211
Depreciation and depletion	**2,202,878**	2,273,478
Taxes (other than income taxes)	**1,503,424**	1,511,661
Retirement plan and group insurance expense	**368,754**	485,074
Selling and general and administrative expenses	**1,918,962**	1,898,358
Non-productive exploration expense	**10,858**	91,939
Interest expense	**274,080**	131,962
Interest charged to construction (Note 1)	**(236,976)**	
Other expenses	**38,442**	30,416
Total	**20,257,131**	21,446,099
INCOME BEFORE PROVISION FOR INCOME TAXES	**5,979,644**	5,879,507
PROVISION FOR FEDERAL AND STATE INCOME TAXES:		
Federal (Note 1):		
Current year	**(761,235)**	1,358,099
Deferred	**2,347,150**	13,000
State	**29,857**	45,657
Total	**1,615,772**	1,416,756
NET INCOME	**4,363,872**	4,462,751
RETAINED EARNINGS AT BEGINNING OF YEAR	**20,391,523**	17,748,768
Total	**24,755,395**	22,211,519
LESS — Cash dividends on capital stock ($1.40 per share)	**1,820,000**	1,819,996
RETAINED EARNINGS AT END OF YEAR (Note 3)	**$22,935,395**	$20,391,523

The accompanying Notes to Financial Statements are an integral part of this statement.

Notes to Financial Statements

1. In accordance with long-established Company practice, certain mine development costs were charged to plant, equipment and leases for financial report purposes but to operating expenses in the computation of the accrual for Federal income tax. Commencing in 1963, interest costs during construction of new properties were treated similarly. The resultant current year tax reduction of approximately $2,276,000 was deferred for amortization over the operating lives of the properties being developed. In 1962, a similar tax reduction of approximately $145,000 was not deferred.
2. Included in plant, equipment and leases at December 31, 1963 are costs of $16,469,409 incurred on the Mineral Park copper-molybdenum property and the Nash Draw langbeinite property now under development and construction and construction contract advances of $2,294,071. The Company estimates that these two major projects will be completed in 1964 at additional costs of approximately $21,000,000.
3. The 5% bank loans at December 31, 1963 totaling $3,000,000 have a stated maturity date of July 1, 1973, subject to a two year extension at the Company's election. Under the loan agreement, additional borrowings not exceeding an aggregate of $22,000,000 may be made. Minimum quarterly payments of $500,000 commencing January 1, 1966 are required and additional annual payments not exceeding $1,000,000 may be required commencing April 1, 1967, such annual payments being contingent upon the prior year's net income and other factors.

   Among other provisions of the loan agreement is a restriction on the amount of retained earnings of the Company available for dividend payments. At December 31, 1963, approximately $5,054,000 of the Company's retained earnings were unrestricted.
4. The Indenture related to the Debentures requires sinking fund payments in an amount sufficient to redeem $1,300,000 principal amount of the Debentures annually commencing in 1976, such required payments being subject to credit for debentures converted to capital stock or redeemed otherwise than through the sinking fund. The Debentures are convertible on and after August 1, 1965, at the option of the holders, into capital stock at the conversion price of $40 per share. The conversion price is subject to adjustment upon the occurrence of certain events as described in the Indenture.

DUVAL
CORPORATION

HASKINS & SELLS
CERTIFIED PUBLIC ACCOUNTANTS

HOUSTON CLUB BUILDING
HOUSTON 2

Accountants' Opinion

TO THE SHAREHOLDERS AND THE BOARD OF DIRECTORS OF
DUVAL CORPORATION:

We have examined the balance sheet of Duval Corporation as of December 31, 1963 and the related statement of income and retained earnings for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet and statement of income and retained earnings present fairly the financial position of the Company at December 31, 1963 and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied (except as explained in Note 1 to the Financial Statements) on a basis consistent with that of the preceding year.

HASKINS & SELLS

January 18, 1964

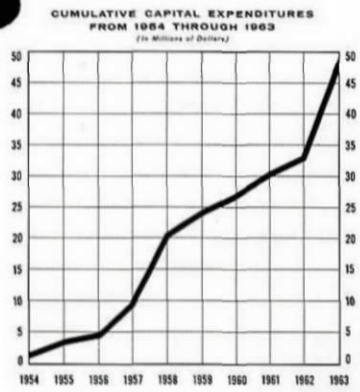
DUVAL

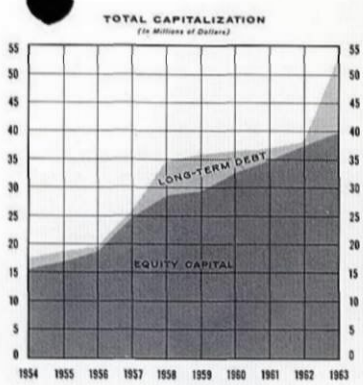
CORPORATION

10 Year Financial Highlights

	1963	1962	1961
FINANCIAL POSITION AT DECEMBER 31			
ASSETS:			
Current assets — In thousands	**$14,975**	$15,319	$14,764
Plant, equipment and leases — Net of reserves — In thousands	**42,950**	26,878	26,274
Other assets and deferred charges — In thousands	**263**	318	518
Total — In thousands	**58,188**	42,515	41,556
LESS: CURRENT LIABILITIES AND DEFERRED CREDITS — In thousands	**5,346**	4,667	4,601
TOTAL CAPITALIZATION — In thousands	**$52,842**	$37,848	$36,955
Composed of:			
Bank loans — In thousands	**$ 3,000**	$ 550	$ 2,300
Convertible Subordinated Debentures — In thousands	**$10,000**		
Equity capital — In thousands	**$39,842**	$37,298	$34,655
EARNINGS RECORD			
Gross revenues — In thousands	**$26,237**	$27,326	$26,306
Total expenses except income taxes — In thousands	**20,257**	21,446	20,606
Earnings before income taxes — In thousands	**5,980**	5,880	5,700
Income taxes — In thousands	**1,616**	1,417	1,596
Net earnings — In thousands	**$ 4,364**	$ 4,463	$ 4,104
Earnings per share	**$ 3.36**	$ 3.43	$ 3.16
Dividends paid — In thousands	**$ 1,820**	$ 1,820	$ 1,625
Dividends paid per share	**$ 1.40**	$ 1.40	$ 1.25
Retained earnings — In thousands	**$ 2,544**	$ 2,643	$ 2,479
Retained earnings per share	**$ 1.96**	$ 2.03	$ 1.91
Annual rate of dividends paid	**$ 1.40**	$ 1.40	$ 1.25
EMPLOYEES			
Number	**797**	775	753
Payroll and payments for account of employees — In thousands	**$ 6,031**	$ 5,736	$ 5,633

( ) Indicates red figure





1960	1959	1958	1957	1956	1955	1954
$15,065	$12,554	$ 9,173	$11,185	$10,579	$10,313	$ 9,946
25,217	25,893	25,807	14,832	9,728	9,552	8,748
621	1,128	1,340	1,368	971	1,011	1,127
40,903	39,575	36,320	27,385	21,278	20,876	19,821
4,677	4,269	1,712	2,241	1,993	2,348	2,606
$36,226	$35,306	$34,608	$25,144	$19,285	$18,528	$17,215
$ 4,050	$ 6,100	$ 6,125	$ 625	$ 1,125	$ 1,625	$ 2,125
$32,176	$29,206	$28,483	$24,519	$18,160	$16,903	$15,090
$31,226	$19,055	$12,631	$13,976	$12,263	$13,362	$13,344
25,385	16,036	10,096	9,925	8,957	9,179	8,925
5,841	3,019	2,535	4,051	3,306	4,183	4,419
1,246	670	(110)	941	799	1,120	1,348
$ 4,595	$ 2,349	$ 2,645	$ 3,110	$ 2,507	$ 3,063	$ 3,071
$ 3.53	$ 1.81	$ 2.03	$ 2.91	$ 2.51	$ 3.06	$ 3.07
$ 1,625	$ 1,625	$ 1,553	$ 1,315	$ 1,250	$ 1,250	$ 1,250
$ 1.25	$ 1.25	$ 1.19	$ 1.23	$ 1.25	$ 1.25	$ 1.25
$ 2,970	$ 724	$ 1,092	$ 1,795	$ 1,257	$ 1,813	$ 1,821
$ 2.28	$ .56	$ .84	$ 1.68	$ 1.26	$ 1.81	$ 1.82
$ 1.25	$ 1.25	$ 1.25	$ 1.25	$ 1.25	$ 1.25	$ 1.25
742	687	537	550	520	532	511
$ 5,261	$ 4,767	$ 4,058	$ 3,969	$ 3,742	$ 3,583	$ 3,254

DUVAL
CORPORATION
1906 FIRST CITY NATIONAL BANK BUILDING HOUSTON TEXAS 77002

Directors and Officers

DIRECTORS

G. E. ATWOOD — Tucson, Arizona
Vice President — Duval Corporation

E. COCKRELL, JR. — Houston, Texas
Independent Oil Operator

EUGENE GERMAN — Houston, Texas
Vice President — Duval Corporation

LEON S. GREGG — Houston, Texas
Vice President — American General Insurance Company

N. C. MCGOWEN — Shreveport, Louisiana
Chairman of the Board and Director
United Gas Corporation

J. H. MIRACLE — Shreveport, Louisiana
Vice President and Treasurer
United Gas Corporation

W. P. MORRIS — Houston, Texas
President — Duval Corporation

ED PARKES — Shreveport, Louisiana
President and Director
United Gas Corporation

R. A. SHEPHERD — Houston, Texas
Partner — Vinson, Elkins, Weems & Searls
Attorneys-At-Law

OFFICERS

W. P. MORRIS, *President*

G. E. ATWOOD, *Vice President*

EUGENE GERMAN, *Vice President*

R. A. SHEPHERD, *Vice President*

W. M. OWEN, *Secretary and Assistant Treasurer*

W. B. WILKERSON, *Treasurer and Assistant Secretary*

H. B. MONDAY, *Assistant Treasurer and Assistant Secretary*

Administrative, Technical and Supervisory Personnel

GENERAL OFFICE - HOUSTON, TEXAS

G. H. BULL, *Chief Accountant*
C. R. JOHNSON, *Internal Auditor*
C. D. RYEN, *Administrative Assistant*

SULPHUR DIVISION - ORCHARD, TEXAS

D. E. COCHRAN, *Resident Manager*

J. T. BURCH, *Field Superintendent*
R. C. MOLLISON, *Purchasing Agent*
E. SELF, *Chief Accountant*
V. M. SPILLER, *Plant Superintendent*

POTASH DIVISION - CARLSBAD, NEW MEXICO

J. E. TONG, *Resident Manager*
M. H. HARRISON, *Assistant Resident Manager and Plant Superintendent*

E. D. BOWMAN, JR., *Process Superintendent*
J. J. GASPARICH, *Mine Superintendent*
A. T. JONES, JR., *Maintenance Superintendent*
B. F. MCGUIRE, *Exploration Geologist*
T. H. PATE, JR., *Chief Accountant*
J. E. SLAY, *Chief Chemist*
J. R. SMITH, *Purchasing Agent*
B. R. WHITTINGTON, *Shipping Agent*

COPPER DIVISION: ESPERANZA PROPERTY - TUCSON, ARIZONA

C. H. CURTIS, *Resident Manager*

J. J. BAILEY, *Mill Superintendent*
M. CUNLIFFE, *Maintenance Superintendent*
T. JANCIC, JR., *Chief Mine Engineer*
G. R. KEMP, *Purchasing Agent*
A. F. LINDSTROM, *Chief Accountant*
R. W. LIVINGSTON, *Chief Metallurgist*
F. M. TINDALL, *Chief Chemist*

COPPER DIVISION: MINERAL PARK PROPERTY - KINGMAN, ARIZONA

I. B. PHILLIPS, JR., *General Superintendent*

S. C. POLASEK, *Chief Accountant*
A. E. SMITH, *Maintenance Superintendent*

EXPLORATION, RESEARCH, DEVELOPMENT AND PLANNING

D. J. BOURNE, Carlsbad, *Director of Research*
J. E. FROST, Tucson, *Chief Geologist*
ROYCE A. HARDY, Tucson, *Development Director*
B. G. MESSER, Tucson, *Administrative Assistant*

DUVAL

CORPORATION

1906 FIRST CITY NATIONAL BANK BUILDING HOUSTON TEXAS

DUVAL

To the Shareholders:

Gross revenues in the first nine months of 1963 were $19.67 million compared with $20.99 million in the same period of 1962. Earnings of $3.24 million, equivalent to $2.49 per share, were down $148 thousand or $0.11 per share from 1962.

Gross revenues from copper and molybdenum were essentially unchanged from 1962 while sulphur and potash revenues were under last year. Copper sales volume was up slightly but sales of sulphur, potash and molybdenum were down from last year. Reduction in gross revenues was offset by a corresponding reduction in costs and expenses, the net effect being that income before provision for income taxes equaled that of last year.

Prices received for all of the Company's products except sulphur have equaled or exceeded prices received in 1962. Sulphur prices in the foreign market continue to follow a downward trend although demand in this market compares favorably with last year. Average price realization from domestic sulphur sales has remained essentially unchanged.

Production of potash and copper increased over 1962. However, moderate decreases have been experienced in the production of sulphur and molybdenum. Operations at all properties were normal during the quarter.

Construction at the Mineral Park copper property is progressing on schedule with several auxiliary buildings nearing completion. The plant water supply system has been completed and the excavation and foundation work for the concentrator and related facilities is well advanced. At the mine, approximately six million tons of overburden have been removed. Construction of the Nash Draw potash project surface facilities is on schedule. Difficulties encountered in penetrating a water-bearing formation have delayed sinking operations on the ore-hoisting shaft at Nash Draw by some two to three months.

The sale of $10 million principal amount of Convertible Subordinated Debentures offered to shareholders in July was completed in early August with the issue being fully subscribed.

Respectfully,

W. P. MORRIS
President

October 16, 1963

BALANCE SHEET / SEPTEMBER 30, 1963 AND 1962

ASSETS

	1963
CURRENT ASSETS:	
Cash	$ 8,863,030
Working funds	38,000
Accounts receivable:	
Customers (less reserve for doubtful receivables)	2,607,832
Other	246,334
Inventories:	
Products (at cost — less than market)	3,771,374
Materials and supplies (at average cost)	1,413,714
Prepayments	51,783
Other	75,985
Total current assets	17,068,052
PLANT, EQUIPMENT, AND LEASES — At cost	54,257,089
Less reserves for depreciation and depletion	18,744,395
Plant, equipment, and leases — net	35,512,694
DEFERRED CHARGES:	
Unamortized funded past service cost of retirement plan	—
Advance royalties	69,002
Public utility deposit	34,349
Mine development costs	535,861
Other	165,223
Total deferred charges	804,435
TOTAL	$53,385,181

LIABILITIES

CURRENT LIABILITIES:	
Current maturities of bank loan	$ —
Accounts payable	1,038,228
Salaries and wages payable	177,932
Accrued liabilities:	
Taxes (see Note)	759,950
Royalties	296,719
Interest	91,175
Other	93,466
Total current liabilities	2,457,470
LONG TERM DEBT:	
Bank loans — Portion maturing after one year	—
4⅝% Convertible Subordinated Debentures due 1983	10,000,000
Total long term debt	10,000,000
RESERVES:	
Deferred Federal income tax liability (see Note)	1,643,430
Repair and maintenance	114,766
Total reserves	1,758,196
CAPITAL STOCK AND RETAINED EARNINGS:	
Capital stock (Authorized 3,000,000 shares at no par value; issued and outstanding 1,300,000 shares)	16,906,250
Retained earnings	22,263,265
Total capital stock and retained earnings	39,169,515
TOTAL	$53,385,181

IT OF INCOME AND RETAINED EARNINGS

R PERIODS ENDED SEPTEMBER 30, 1963 AND 1962

	NINE MONTHS 1963	1962
wances, etc.	$19,438,819	$20,803,516
	235,912	188,624
	19,674,731	20,992,140
loading and shipping expenses	10,642,959	11,490,282
etion	1,631,194	1,755,880
me taxes)	1,146,716	1,156,190
roup insurance expense	245,484	499,478
d administrative expenses	1,457,244	1,471,109
ation expense	10,345	24,933
	138,142	106,080
nstruction (see Note)	*101,038 Cr.*	—
	25,491	11,411
	15,196,537	16,515,363
ISION FOR INCOME TAXES	4,478,194	4,476,777
AL AND STATE INCOME TAXES (see Note)	1,241,452	1,091,777
	3,236,742	3,385,000
AT BEGINNING OF PERIOD	20,391,523	17,748,768
	23,628,265	21,133,768
capital stock	1,365,000	1,364,995
AT END OF PERIOD	$22,263,265	$19,768,773
OUTSTANDING	$ 2.49	$ 2.60
SHARE OUTSTANDING	$ 1.05	$ 1.05

g Note to Financial Statements should be considered in conjunction with this statement.

cial Statements

e development are being charged of properties not yet in operation the case of properties in operarrowed for construction is also ccount during the construction e tax purposes, however, these

tax liability. The amount of such tax reduction, aggregating approximately $1,604,000 for the nine months ended September 30, 1963, has been deferred from income by crediting a reserve for deferred Federal income tax liability. In the same period of 1962, a reduction in current tax liability of approximately $143,000 resulting from expensing major mine development expenditures for tax purposes was not deferred

DUVAL

CORPORATION

DUVAL

CORPORATION

Quarterly Report

SEPTEMBER 30, 1963

The statements contained herein have been prepared without audit and are subject to year end adjustments, if any, upon examination by independent public accountants.

file "Duval" or Esperanza

W.E.S.

THE ARIZONA DAILY STAR

OCT 13 1965

Esperanza 8-17-62

Duval Cu – 11 lb per ton — 12000 Tpd

11 x 25 = $2.75 net smelter

Costs

mining	.55	net smelter	2.75
milling	.75	less	1.80
indirect	.50		
	1.80		$.95 operating profit

(assume only profit pays royalty of 5%)

$.95 x 4,000,000 (tons ore per yr.) = $3,800,000

assume 50,000,000 ore reserve, $25,000,000 capital
12 year life

Op. profit per yr – $3,800,000
deprec. .50 per ton 2,000,000
1,800,000

US Income tax (.5 x 1,800,000 x .52) = $450,000

Earnings per yr. after taxes – $3,350,000

Capital cost per dollar of annual earnings – $7.50

Return on investment (discounted to present value) 8%

" " @ 2¢ Cu 6%

4-13-62

Notes on Visit to Esperanza - 4-4-62

Present pit bottom — 3900 bench - (35' benches)
Ultimate pit bottom - 2700 (?)
Current stripping - w/o - 1:1.1

Ore types

(1) Meta-sediments — qtzite, congl. & tuff (?)
Generally low grade - (± .2 - .4 primary - sparse enrich)
- May correlate with Tasquela Fm. (Ash Creek Red beds)
- although marginal Cu grade - contains good moly - up to .09 MoS_2 — average: .04?

(2) Quartz mong. por. — strong qtz-ser alteration - but biotite generally visible — Rock is tough except where cut by fissures. Contains .6 to .7 primary Cu, but little enrichment. Bench face showing base of oxidation contained mong. with cc only in a few wide space fissures.

(3) Andesite - Deane Lynch says post mong intrusive — low in primary but good enrichment

35% 1/3 of ore (2) Relatively hard to crush and grind
15% 1/6 of ore (3) no problem
50% 1/2 of ore (1) dense flinty appearance, but no grinding difficulty

Types (1) and (3) occurred in area of under ground workings - no monzonite tested in pilot pla

NW extention contains +/5 mill to - monzonite with some enrichment — capped by so-called volcanics — banded flinty rock — mela seds? or meta-pyroclastics? —

Lynch Seg: granodiorite appears to pre date sediments — may thus correllate wit clastics at Silver Bell —

JHC comments
3-27-5-8

Visit April 13, 56 — Duval Sulphur
with K.R. & Owen Evans

Plan map shows "blanket ore"
approx 3000' x 2500' —
av capping — 100–125'
av ore – secondary 100–125'
primary ?

Have two areas primary – ± 800' dia
Ore body ± 50 mil tons @ .70
grades in ore body for holes
range from .37% to 1.5% Cu
"Moly is twice that of av. for copper"
used 30 cent Cu to calculate outcrop

Some of ore is oxidized – some capped
with silicates —
secondary blanket follows topog

ore occurs in mp as well as in
dark porphyry — exposures in
cuts on north side show east-
dipping zones of alternating of very
weak and strong alt dark rock
"granulite" — looks like mica
quartz – met rock often seen in
inclusion in granite —

Now have 2 DD + 2 churn drills
on wide spaced and infilling holes —
Continuing check wk in adit

over

Aug 22 – Harrison Schmitt:
Drill 10 CDH on 250' centers – checked
within 15%. —
Raise & weirs ± 400' on 4 holes
2 DDH + 2 CDH —
Raise results 9% lower than DDH
" " 8% higher " CDH
but top of ore was higher than
(10') shown by CDH — so comparing
sample to sample the check was
fairly close —

About 40 holes in ore body —
average NS about .05
but some erratics —
Recovery about 85% (mill)

FILE MEMORANDUM

March 27, 1958

ESPERANZA MINE
(DUVAL SULPHUR)
PIMA COUNTY, ARIZONA

A visit to the Esperanza Mine was made on March 24. Don Kleppinger and Bill Roper, geologists, acted as guides. The following consists of a general summary of information, principally on ore reserves and geology, available to date.

Mill construction (Stearns Roger) and stripping (Isbell), started last year, is now well under way. Production of copper is expected to commence in the spring of 1959.

	Tons	Grade
Total Reserves.	47,000,000	.68% Cu
Average moly content.		.02 MoS_2
Stripping ratio, w/o.		1/1
Pre-mine stripping. . . .	5,000,000 tons	
Milling rate.	10,000 tpd	
Mill recovery	87%(?)	
Capital Investment.		$20,000,000.

A bench height of 25 feet was first considered, but they will probably use 35 feet for both waste and ore. Much of the rock drills and breaks easily; some of the capping however is quite hard. The rotary drills are penetrating this material successfully, but bit consumption is high and progress relatively slow.

GEOLOGY

A general review of geologic features accompanied by a small scale geologic map of the district (entitled New Years Eve area, Twin Buttes district) was written November 28, 1955. A copy of this memo is attached for reference.

In brief, the Esperanza deposit consists of a rather flat-lying secondary chalcocite blanket, a portion of which is underlain by ore-grade primary chalcopyrite mineralization. The chalcocite blanket varies somewhat in thickness, but averages about 120 feet. The outline of the open-pit ore body -- about 1500 ft. by 2600 ft. in horizontal dimensions -- is essentially an economic limit, a line drawn where the blanket becomes too thin or low grade to support the necessary stripping.

The three principal host rocks are: a so-called graywacke (sandstone), an andesite intrusive and a monzonite porphyry intrusive. The graywacke is actually a conglomerate composed of angular and rounded fragments and is probably a part of the andesite porphyry conglomerate (Silver Bell type) which underlies Tertiary Cat Mountain rhyolite at Silver Bell, in the Tucson Mts. and elsewhere. Both intrusives cut through the conglomerate as irregular masses, dikes and sills, the andesite being the earliest of the two.

The copper occurs as chalcocite and chalcopyrite, associated with some pyrite, as discrete grains and very thin fracture fillings. Veins are rare to absent. Of note is the relative favorability of the andesite to primary copper mineralization. It was stated that, beneath the chalcocite zone, it contains an average of over .50% copper, while the monzonite and conglomerate average around .20% copper. As might be expected, the andesite also contains the strongest secondary copper (up to 1.5% cu). Further, the andesite is less altered in appearance, being a dense black to greenish rock -- an appearance probably due to the abundance of hydrothermal biotite.

As pointed out in the attached memorandum, the outcrops over the deposit are composed mainly of dense siliceous appearing conglomerate with only relatively small areas exhibiting appreciable amounts of limonite after chalcocite. The explanation for this anomalous condition is now apparent: the conglomerate contained relatively less copper, either as secondary, or primary, prior to leaching; but due to its relative resistance to erosion, it comprized the bulk of the outcrops in the area. However, in the matter of interpretation of leached outcrops, the buried andesite, now exposed by the stripping in the oxide zone, offers a problem in that it shows very little evidence of pre-existing sulphides of any kind. The average exposure is a pale to dark greenish, chloritic looking rock, apparently unmineralized. Likewise, it was difficult to find copper sulphides or pyrite in andesite ore in the piles of rejects from the underground sampling. Consequently, the chalcocite must occur largely as microscopic grains; but even so, the pyrite content appears far too low to have provided sufficient acid for extensive leaching. It might be theorized that the acid could have been derived from either the monzonite or the conglomerate, both of which contain possibly 3.0% to 5.0% pyrite -- approaching the percentage found in the average enriched porphyry copper deposit.

Exploration of the deposit (principally by churn drill) was carried out on a 500 foot leg, equilateral triangle grid. Subsequently two pairs of triangles were checked by drilling 5 interspaced holes in each pair (250 ft. equilateral spacing of holes). This area checked by the closer spaced holes amounts to about 12% of the ore deposit. It was stated that in the case of one pair of 500 ft. triangles, the check holes gave lower results; in the other, the results were about even. Also one check hole encountered 235 feet of oxidation -- much greater than the average depth of capping which is 95 feet. Although we have little information on the degree of uniformity of mineralization indicated by the drill results, it would seem that additional drilling on 250 foot spacing would be required in order to produce a reasonably firm estimate of grade, tonnage and location of pit perimeter; but the Duval Company apparently has no plans for additional interspaced drill holes.

To test the accuracy of the churn drill samples (holes were cased at 30 foot intervals) an adit was driven to one hole, and three other holes reached by 1500 feet of drift. Bulk samples obtained from the raises on these four holes reportedly checked closely with the drill results.

The grade of the Esperanza deposit is obviously marginal, requiring not less than a 30¢ copper price to show even a small margin of profit after return of capital -- assuming average operating conditions. However, certain favorable factors exist which will contribute substantially to lower than average overall costs. Among these are: (1) Favorable topography for low tonnage pre-mine stripping and for a short downgrade haul to the mill, and (2) favorable position with respect to transportation of concentrates and materials, and to living facilities, eliminating the cost of housing.

It is reported that the grade of the ore for the first four years of production will be .77% copper. If so, the balance (say 10 years) will presumably average .65% copper.

J. H. Courtright

J. H. COURTRIGHT

cc: DJPope
LWHart
KERichard

Aa 16.16.0

FILE MEMORANDUM

November 28, 1955

NEW YEARS EVE AREA
TWIN BUTTES DISTRICT
PIMA COUNTY, ARIZONA

Since May of this year the Duval Sulphur Company has been drilling the Wilson property in the vicinity of the New Years Eve mine, situated 5 airline miles southwest of Twin Buttes. According to local rumor, they have found a low grade chalcocite ore body in the area between the New Years and Amargosa Mines.

It was learned recently that 22 holes averaging about 500 feet in depth have been completed. At present, six drills are operating two shifts each per day. Three of these are Joy contract diamond drills and three are churn drills (two Purcell and one Wininger). Due to the character of the rock formation -- generally silicified and hard, with frequent broken zones subject to caving -- drill progress has been poor, averaging around 10 or 12 feet per shift for both types of drilling. Churn drill holes are cased on 30 to 40 foot intervals.

The occurrence of disseminated copper mineralization in this area has been common knowledge for some time. The record dates back to 1907 when Calumet and Arizona tested the Amargosa with 4 diamond drill holes. A few years later the Magnate Copper Company churn drilled 3 holes in the Esperenza (Calamina) area (see map attached). More recently (1944), the U.S.B.M. sampled the New Years underground workings and put down 3 diamond drill holes on the Amargosa, and in 1950 Coronado (Cypress) drilled 3 or 4 holes (churn drill) in the vicinity of the early drilling at Esperanza.

None of this exploration was successful. The U.S.B.M. reported (R.I. 4016 - Stanley Tainter) an average of around .03% moly and .30% copper for the 1500 feet drilled at the Amargosa. Results at the New Years indicated about 60,000 tons of .60% copper down to the 200 level.

The district is situated in a group of low lying hills, well down on the east flank of the Sierrita range of mountains. Paleozoic sediments, granitic rocks and Tertiary volcanics comprise the main bedrock formations of the region. The low hills in the New Years area are composed principally of the volcanics -- pyroclastics and conglomerates -- cut by small masses of intrusive monzonite porphyry. The volcanics are obviously earlier than the porphyry, but are probably later than the main granitic intrusive.

Alteration, accompanied by disseminated sulphide mineralization occurs in the volcanics and granitic rocks over an area of about three square miles. The approximate limits of this zone are shown on the attached map. In general, the outcrops show evidence of predominantly pyritic mineralization as disseminated grains; veins or mineralized joints are extremely rare, except in the New Years Mine. Small areas of mineralized breccia occur at the Esperenza and Amargosa. Minor amounts of limonite after chalcocite have been observed in the outcrops around

these two prospects. In the area now being explored by Duval the rocks are mainly silicified pyroclastics or conglomerates. Outcrops and road-cut exposures display dense, flinty textures for the most part, with evidence only of generally weak primary and secondary copper mineralization. In many respects these outcrops closely resemble those of Portland ridge on the south side of the Oxide deposit at Silver Bell. However, as noted above, veins or mineralized joints are almost entirely lacking. Also, the New Years outcrops commonly show some pyrite, indicating incomplete leaching of the dense, silicified rock.

The occurence of appreciable thicknesses of chalcocite enrichment beneath such outcrops is to be regarded as a somewhat anomalous condition. That is, the character of the limonites and alteration in outcrops is not indicative of an underlying body of ore-grade materal. However, judging from the existing pattern of drill holes (drilled on a 500-foot triangular grid), it is possible that they have a low grade ore body some 500 to 1000 feet wide and 1500 feet long. According to information obtained from drillers, the leached capping varies from 300 feet in thickness along the ridge crest to 100 feet lower on the slopes. If so, the ore might range from 100 to 200 feet thick in a body of 10 to 20 million tons.

During my recent, brief visit to the property it was learned that three of their holes drilled near the Amargosa gave results similar to those obtained by the U.S.B.M., and that much of the wide spaced drilling (1000 to 1500 foot spacing) was also negative. Although preparation of inter-spaced drill locations was not in progress, Mr. Messer stated they probably would do such drilling by placing holes at the mid-point of each triangle leg.

Harrison Schmitt (consultant for Duval) stated that he regards the "chalcocite body" as an erosional remnant since unenriched primary mineralization is exposed in the canyon bottoms around the deposit. It was further indicated by his remarks that substantially all the ore occurs in the silicified volcanics, rather than in the porphyry.

An effort will be made to obtain more information about this presumed ore body in order to try to determine why its existence was not indicated in outcrops. It is possible that some other alteration zones now classed as having no commercial possibilities should be re-evaluated in this connection.

J. H. COURTRIGHT

cc: FVRichard
WRLandwehr
TASnedden
KERichard
File-2

Duval Sulphur

from R F Welch

Nov. 5, 1957

planning 10,000 ton plant to start production - March '59.

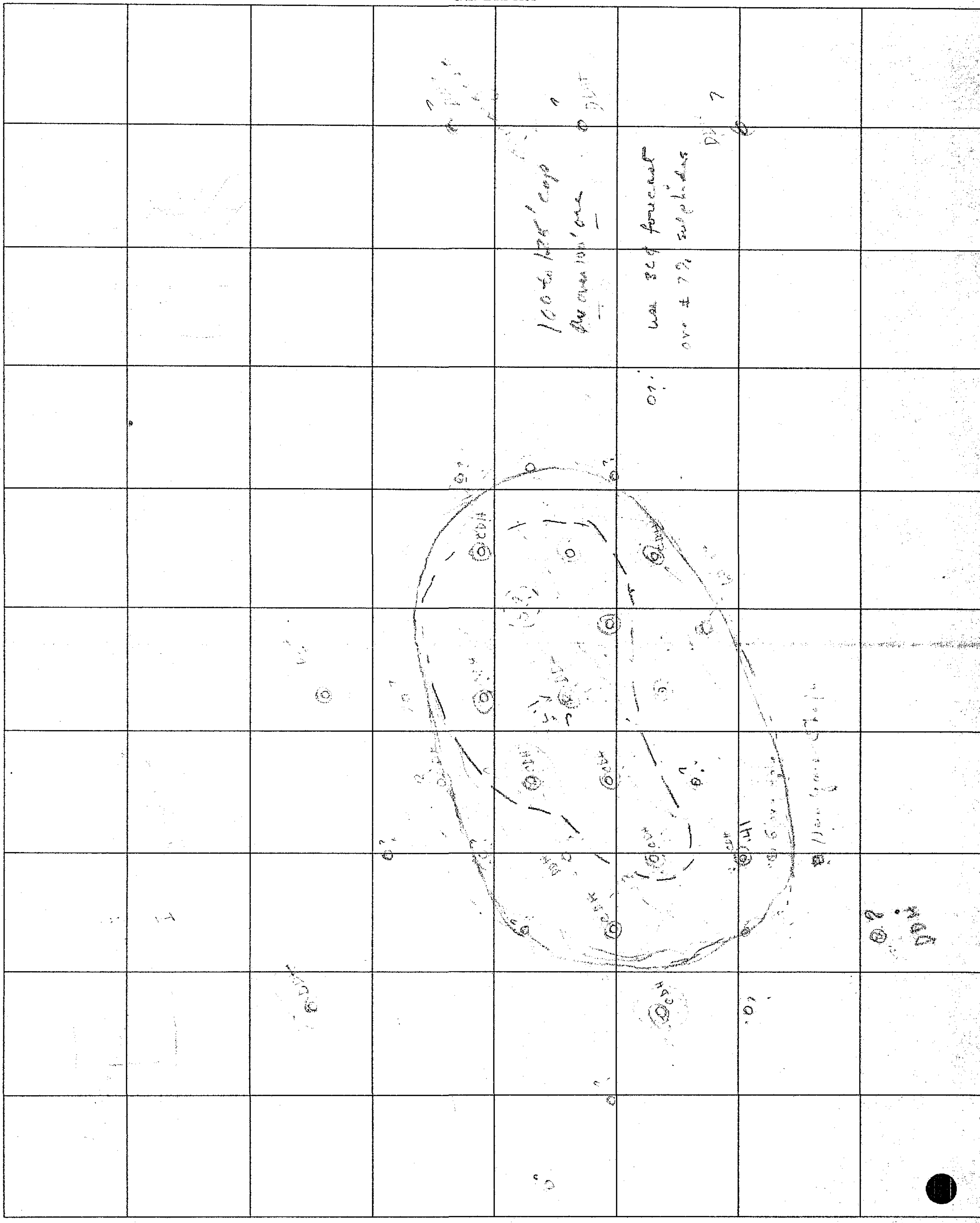
Requesting 15 yr contract —

Rcts on:

Ore % Cu	Recov	Conc. Grade
.77	80%	20%
.80	85%	25%

Published reserve — 40 mill @ .65% Cu

SALT LAKE BLUE



FORM 1006

MINE ____ LOCATION ____ LEVEL ____

GEOLOGY BY ____ SURVEY ____ SCALE ____ DATE ____

MINE _____ LOCATION _____ LEVEL _____

GEOLOGY BY _____ SURVEY _____ SCALE _____ DATE _____

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

February 15, 1954

MEMORANDUM FOR MR. KENYON RICHARD

NEW YEAR'S MINE
Pima Dist. (Twin Buttes Area)
Pima County, Arizona

During reconnaissance in the Twin Buttes area on February 10, Mr. Papke and I visited the New Year's Mine which was reported in R. Welch's December Field Notes as having shipped one car of 5.00% copper ore. Mr. Val Nuttall, foreman, took us underground for a brief inspection of the workings.

The copper, chalcopyrite with minor molybdenite, occurs in and near a siliceous pegmatite zone in porphyritic granite. The ore is found in discontinuous, high grade pods within massive quartz and within highly silicified porphyry. A prospect raise (SW at plus 55 degrees) encountered 10% copper ore at 50 feet above the 200 level. At 60 feet the face is still in strong chalcopyrite mineralization. This occurrence is probably another small pod, but it is quite possible that it will produce at least several cars of shipping grade. This new discovery is in silicified porphyry, 20 feet or more southwest of the pegmatite "dike".

Past production has been insignificant and it appears unlikely that future production will exceed two or three cars per month.

A Bureau of Mines sample map (1947?) showed drift assays averaging about 1.0% copper and .15% molybdenum on the 200 and on the two levels above. Judging from our examination of the surface and of the workings the zone carrying these values (disseminated in the porphyry) may have horizontal dimensions of at least 100 x 200 feet. Outside of these limits there is less evidence of sulphide mineralization and comparatively weak alteration.

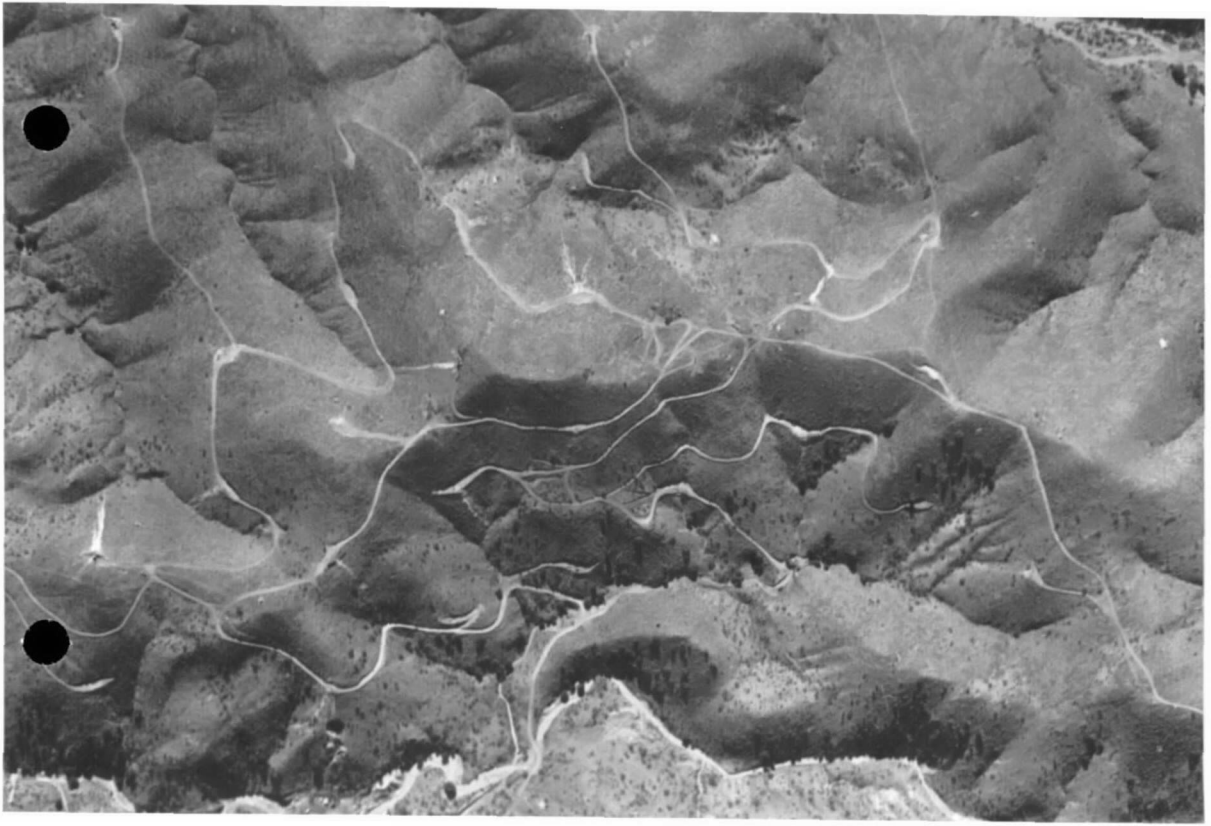
J. H. C

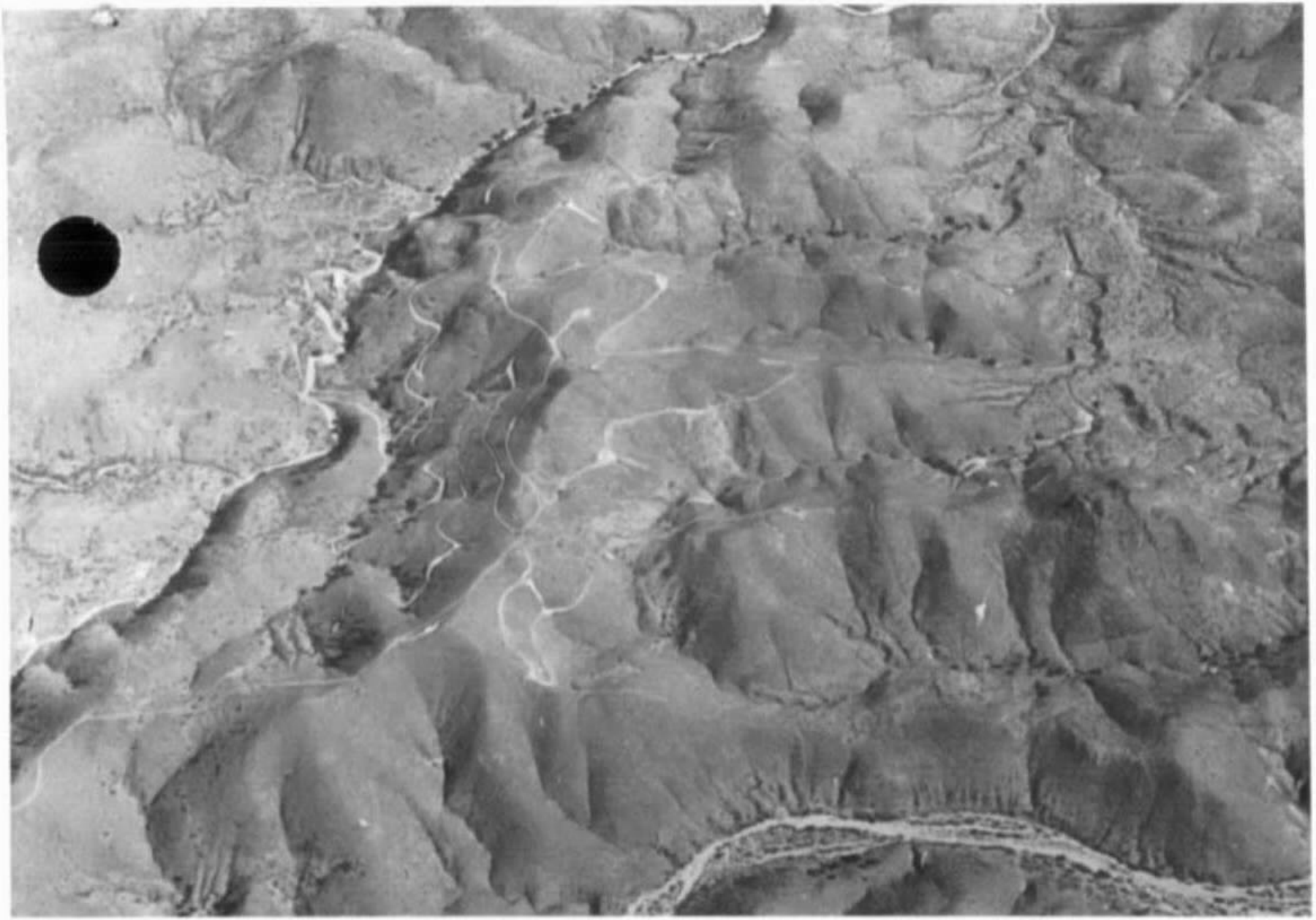
JHC:ar

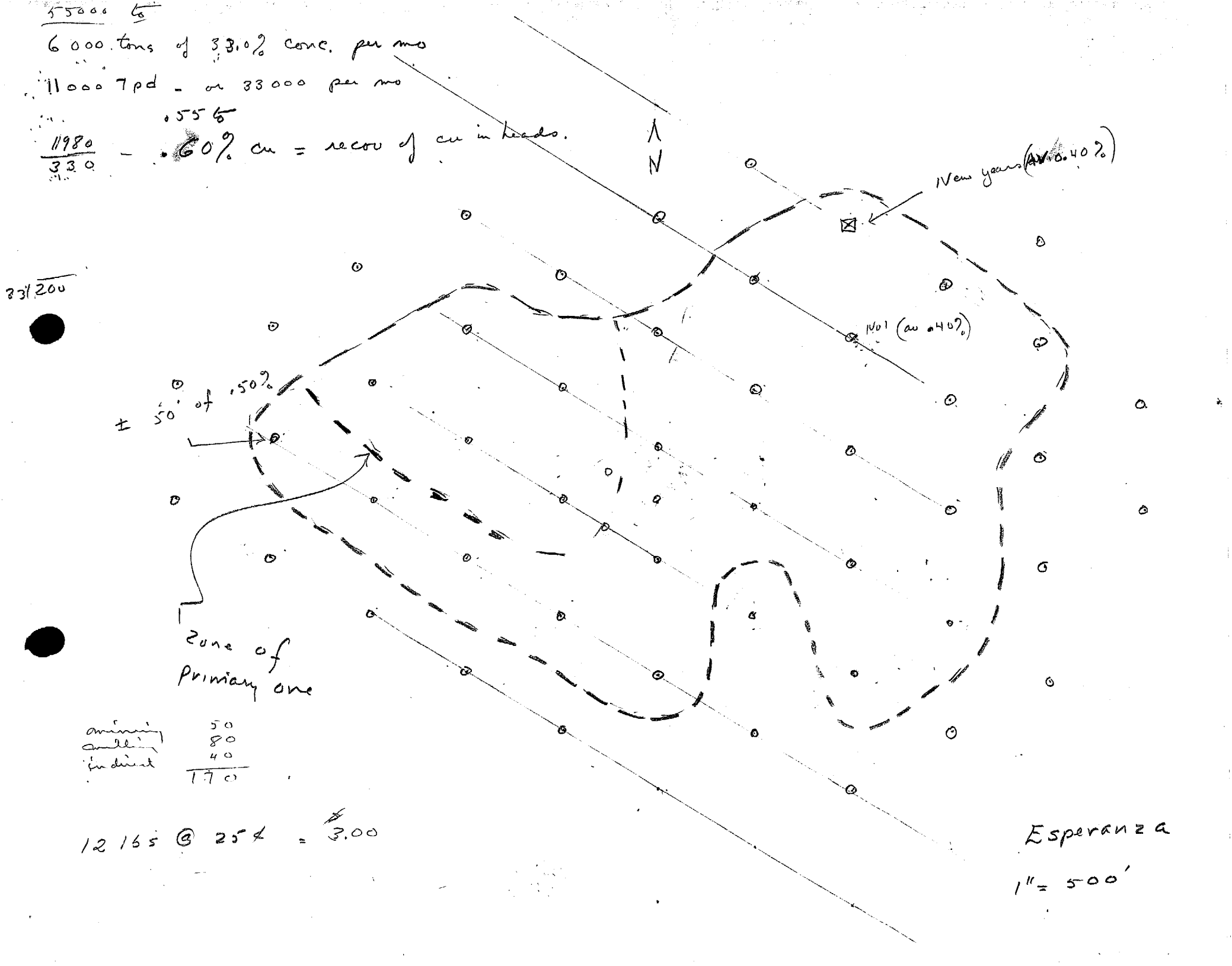
J. H. COURTRIGHT

cc: TASnedden
RFWelch

2 muck samples from low grade portion of raise run 0.24 % Cu






55000
6000 tons of 33.0% conc. per mo
11000 Tpd - or 33000 per mo
.55
11980 / 330 - .60% cu = recov of cu in leads.
N
New years (Av 0.40%)
No1 (av .40%)
± 50' of .50%
Zone of Primary ore
mining 50
milling 80
indirect 40
170
12 165 @ 25¢ = 3.00
Esperanza
1" = 500'

Relative Reliability of Rotary Drill Sampling Against Churn Drill Sampling

By G. E. Napp

When asked to prepare a paper on Churn Drill and Rotary Drill sampling, it was felt the best we could do in the time available, was to match the assays achieved by the two methods, against our mill heads and corrected grade. The churn drill assays were examined over the first two years of Copper Cities production and the Rotary's over the following two years. Both types of drills were drilling nine inch holes in similar ground. The Mine grade was 7.44% higher during the first two years.

Churn drill blast hole drilling terminated at Copper Cities in August, 1956. The machines were equipped with a dump box and a splitter, which took a 1/12 cut out of each bailing by means of a single slot in the bottom of the launder. When the hole was down to grade, this retained 1/12 fraction was then cut in a Jones splitter to approximately one gallon of sludge.

A 40-R Bucyrus Erie Rotary Drill was put into service in August, 1956. This drill utilizes a 600 CFM single stage compressor, at 35 lbs. pressure for cleaning holes. A wedge shaped container is used to catch the sample. The narrow end of the can is placed normal to the hole casing so as to catch a representative portion of the hole cuttings. The container is 12" high, $2\frac{1}{4}$" in width at the small end, 10" at the wide end, and each leg is $24\frac{1}{2}$" long. This sample is also pulled at grade and cut to size in a Jones splitter.

To arrive at a mine grade, the average of the blast hole assays in each shot is applied against the tonnage mined from that shot. A blast hole assay represents about 4,000 tons of material.

The mill heads are obtained by taking a manual sample of the Ball Mill feed every 30 minutes at each mill. These samples are combined at the end of the shift for a shift assay.

A corrected grade is calculated by adding the pounds of copper lost in the tailings to the gross pounds of copper credited to us by the smelter. This is divided by the pounds of dry mill feed. An automatic sampler is used for the tailings sample.

The following chart shows the results of our investigation:

Per Cent Variation of Mine Grade against Mill Heads and Corrected Grade

Churn Drill Sampling

	Mill Heads	Corrected Grade
August, 1954 - July, 1955	-1.22%	-1.93
August, 1955 - July, 1956	+0.88	-0.75
Assay Average for the 2 years	-0.12	-1.35

Rotary Drill Sampling

August, 1956 - July, 1957	+3.68	-0.52
August, 1957 - July, 1958	+2.52	+1.53
Assay Average for the 2 years	+3.04	+0.54

Mr. J. J. Spencer presented a paper, ORE SAMPLING AT CASTLE DOME, at the Arizona Section AIME meeting in 1951. This paper was later published in the April 1951 issue of Mining Engineering. For one phase of this paper, tests were run comparing flat valve and dart valve bailers. The reason for this test was to check the possibility of values being shaken to the bottom of the hole through the bumping of the tools: In 16 holes, the flat valve assays averaged 9% more than the dart valve assays. These holes were in a disseminated chalcocite area. In 19 holes, drilled in a disseminated chalcopyrite area, the flat valve assays were 2% less. Evidently, some assays values were being lost in the bottom of the hole in the chalcocite areas. The ability of a Rotary Drill to blow a hole clean could be a partial explanation of the Rotary assays running higher than those of the Churn Drills.

Esperanza

COPPER DIVISION

DUVAL SULPHUR & POTASH COMPANY

TUCSON, ARIZONA

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The old New Year's Eve mine made the first actual penetration into what is now Duval's Esperanza property. The original workings were reactivated briefly during the years of World War II. This recent effort failed to develop sufficient high grade ore for profitable small mine operation, even though traces of molybdenum mineralization were found.

By late summer of 1954, local mining interests had accumulated the 150 mining claims which cover the present ore body and adjacent areas.

Prospecting and Development

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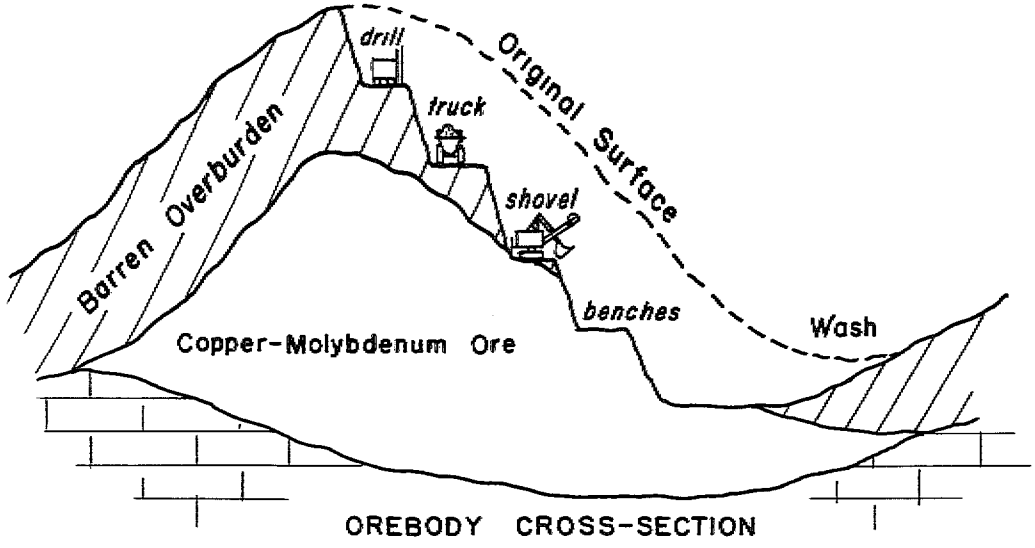
Detailed metallurgical studies were conducted concurrently. Process development proceeded from the laboratory to a pilot plant. Basic flowsheet drawings were prepared for the recovery of both copper and molybdenum.

A construction contract was awarded June 29, 1957 for the concentrator and related facilities. Pre-mining stripping operations began in November

of 1957 to remove 6 million tons of barren overburden to expose enough of the ore body so that routine bench mining could proceed. Both stripping and construction were completed by late February of 1959 and the first ore was fed into the process equipment.

Mining Practice

The ore body as outlined by the drilling program is roughly contained in a Sierrita Mountain foothill which is some 350 feet high and 4,000 feet long. The mineralized section is covered by a blanket of barren overburden varying in thickness and averaging around 100 feet.



OREBODY CROSS-SECTION

The mining practice is the standard bench operation typical of open pit mines. Blast holes are drilled along the bench face and loaded with ammonium nitrate explosive. After detonation, the shot-down face is loaded with 5 cubic yard electric shovels into 40-ton diesel trucks.

The nature of the deposit is such that waste rock must be continually removed to expose fresh ore for mining. The ratio of waste removed to ore mined, generally referred to as the stripping ratio, will average about 1 to 1 over the life of the ore body. Thus, for the daily 12,000 tons of ore hauled to the concentrator, a like tonnage of waste goes to the dump.

Careful assaying, mapping and mine planning are necessary to assure continuous daily production of ore, a low stripping ratio and a minimum loss of ore values to waste.

Milling Practice

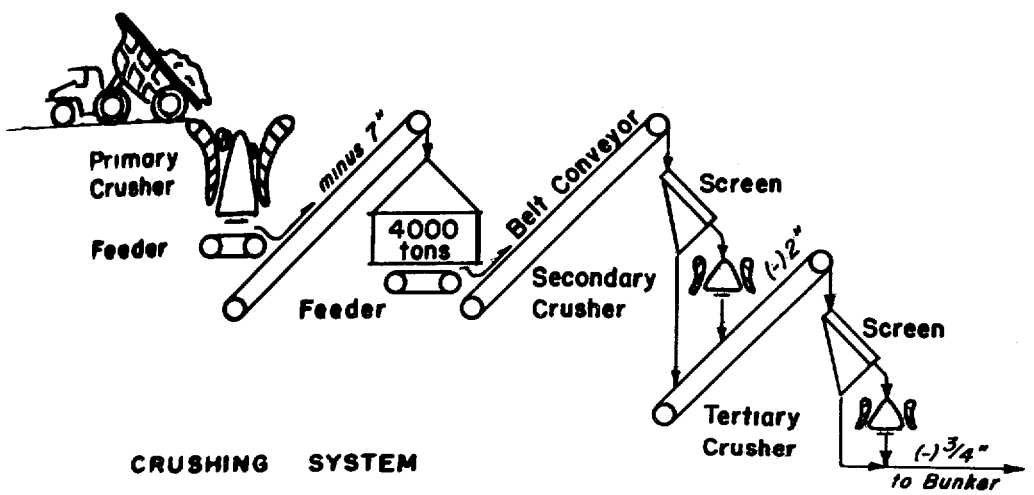
A. Crushing

Mine run ore contains finely disseminated crystals of the black copper sulfide mineral chalcocite along with lesser percentages of the so-called

oxide minerals of copper. Total copper concentration in the ore averages less than one percent. Also present in addition to the copper minerals, is a significant quantity of the molybdenum sulfide mineral called molybdenite. Molybdenum metal concentration is expected to average 0.022% throughout the ore body.

The first refining problem is size reduction to unlock the mineral crystals from the mother rock and to reduce such crystals to dimenions suitable for flotation.

The mining method produces broken rock up to 4 feet in size. Primary crushing of this material is done by the 48 inches gyratory crusher which is housed in its seven-story building.



CRUSHING SYSTEM

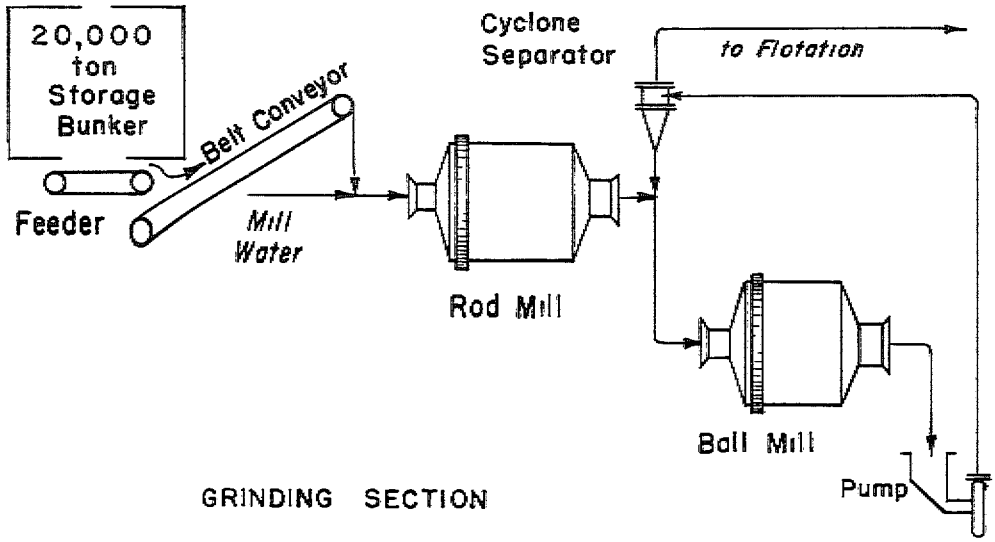
The primary crusher reduces the ore to a maximum size of 7 inches. Further size reduction is carried out in two stages by similar gyratory crushing machines of smaller size. Dry crushing ultimately reduces the particle size to less than 3/4 inch. This material is transferred by belt conveyors to the 20,000-ton storage bunker at the head of the concentrator.

Throughout the crushing system dust collectors are used at all crushing and transfer points to prevent loss of fines and eliminate a serious housekeeping problem.

Electronic instrumentation has been used throughout the system to provide maximum capacity without overload.

B. Grinding

Further size reduction to less than 1/100 of an inch is accomplished in large wet grinding mills. Crushed ore from the 20,000-ton storage bunker is fed to two of the worlds largest rod mills at the rate of 250 tons per hour each. Sufficient water is added with the feed to give the resulting pulp fluidity and the desired pulp density or percent solids.



GRINDING SECTION

The rod mill discharge is split to two ball mills wherein further and final size reduction is accomplished. The ball mill discharge is pumped with a slurry pump to the primary cyclone separators. These devices make a size classification and send the ore of desired fine size forward to flotation and return any oversize back to the ball mills.

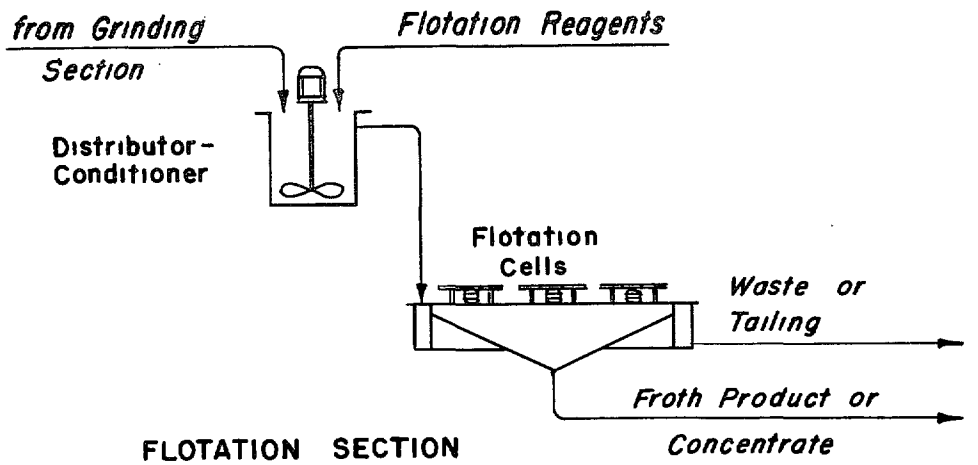
These grinding mills have outside diameters of thirteen feet three inches. The rod mills are sixteen feet long and each is charged with 130 tons of steel rods. The ball mills each carry 150 tons of steel balls. These tonnages of grinding media are maintained by periodic additions equal to the weight of metal which is worn away in the grinding of the ore. The recharging averages some eight tons of steel per day and is one of the major costs in the milling operation.

Here again in the grinding section the use of recording and control instrumentation is evident. These sensitive instruments keep a constant vigil on each phase of the section to assure maximum efficiency and reliability.

C. Flotation

Having accomplished the desired size reduction, next begins the important task of separating the valuable minerals from the mother rock.

The primary cyclone discharge enters the distributor-conditioners where the flotation reagents are added. These reagents, ignoring the gangue rock, selectively seek out the valuable minerals and are adsorbed on their surfaces. Once adsorbed they effectively resurface the mineral and alter the surface characteristics to one having a water repellent, air-loving nature.



FLOTATION SECTION

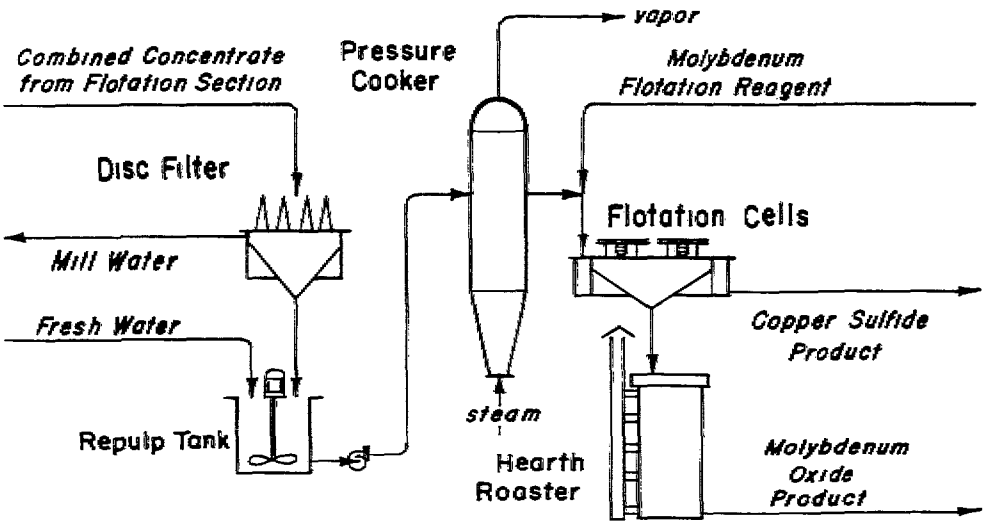
From the conditioner-distributor the reagentized slurry enters the long trough-like flotation cells. The cells provide agitation such that the mineral particles are gently suspended in the water carrying medium. Air is introduced into each cell below the agitator resulting in a multitude of small bubbles rising through the suspended slurry. The reagentized minerals are attracted to the bubbles and floated to the surface of the cell. Additional reagents are added to provide a stable froth on the cell surface wherein the floated mineral collects and overflows the cell lip. Additional flotation steps are required to further refine the flotation product to the desired chemical purity.

The mother rock, unaffected by the action of flotation, moves from cell to cell down the series and ultimately discharges out the bottom of the last cell in the row.

D. Molybdenum Recovery

Both of the principal products, copper and molybdenum, plus a trace of silver are concentrated in the flotation product. The problem of separating molybdenum is one of destroying the reagents used initially to make the copper-molybdenum minerals float and then reconditioning for specific molybdenum flotation.

This is accomplished by first filtering the reagent contaminated mill water from the combined concentrate and repulping with fresh water. The resulting slurry is fed to a giant pressure cooker wherein the reagents coating the minerals are distilled away. To the then sterile pulp is added a collector selective for molybdenum and flotation is again conducted. The froth product from this step is the molybdenum sulfide, while the tailing is the final copper product.



MOLYBDENUM RECOVERY SECTION

The molybdenum sulfide concentrate is then fed to the ten-hearth roaster where it is oxidized to the oxide form for sale to the metals trade.

E. Copper Concentrate Shipment

The final copper concentrate, the unfloated mineral from the molybdenum flotation section, is filtered and conveyed by belt conveyor to the storage house adjacent to the mill building.

Each day the accumulated tonnage is weighed into trucks for transport to the railhead some eleven miles away from the plant. At the siding the trucks dump into open gondolas for shipment to the custom smelter.

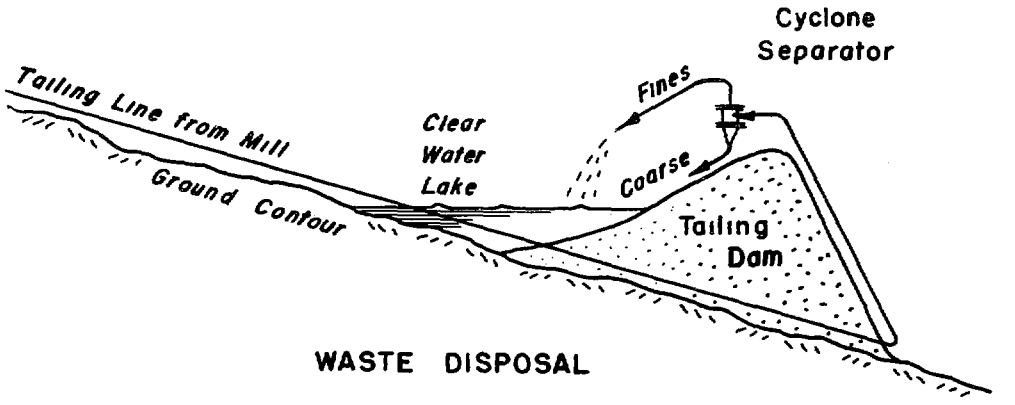
This concentrate, sold as such to the smelter, contains between 25 and 35 percent copper and three to four ounces of recoverable silver per ton.

F. Gangue Tailing Disposal

The mother rock waste leaving the plant presents the dual problem of ultimate disposal and water reclamation.

The magnitude of the disposal problem can be appreciated when one considers that nearly the entire 12,000 tons per day of finely ground plant feed must be disposed of every day for the life of the property. Obvious too, is the fact that if the water used to transport this waste away from the immediate vicinity could be salvaged for reuse, a tremendous saving in both money and a precious natural resource would result.

An adroit solution to these problems has evolved through the years.



WASTE DISPOSAL

In essence, it takes advantage of a gravity flow tailing line to provide feed to the tailing cyclones. The cyclones discharge their relatively course underflow on the top of the growing dam and there compact. The relatively fine, clayey overflow discharges inside the dam. The fines settle out making a water tight seal against the dam and the clear water forms in a back lake for reuse in the milling process.

Instrumentation

Various types of industrial instrumentation have been used throughout the entire processing facility. Where ever possible the tasks of operating personnel have been replaced by electronic-pneumatic recording and control devices. In addition to providing process records for metallurgical study, these controlling instruments sense process upsets imperceptible to human beings and constantly react to maintain desired equilibrium. In this manner the duties of the operating personnel have been largely reduced to that of an attendant. Each section of the plant has a central station where both power and process controls have been assembled in consoles and graphic panels. In this manner the scope of each operator is expanded without sacrifice of either efficiency or reliability.

One example of applied instrumentation is in the operation of the water field system. Water wells are located some six miles from the plant proper. Level control devices at the plant sense the process need for more or less fresh water. An automatic control signal is sent by radio to the water field where unattended pumps correct for the need.

Another example of the use of automatic control is in the molybdenum recovery section. Here a combination of flow, density, level, pressure and temperature measurements are integrated to maintain the desired metallurgical condition in the pressure cooker. The attendant operator functions only when process upsets and mechanical failures are beyond the range of the control devices. In such an event both light and sound alarms function to alert the operator.

Exploration

The Copper Division conducts an intensive exploration program to augment the metallic mineral reserves of the company. Scouting personnel are on constant alert for areas and properties worthy of field party reconnaissance. Property evaluations are made by an exploration team that includes geologists and mining engineers. Advantage is taken of the most recent advances in methods, equipment and geochemistry.

Research

Modern laboratory facilities are equipped not only for routine analysis and process control, but also for research in the mineral dressing field. Those studies that apply directly to copper metallurgy can be transferred from laboratory scale directly into the plant for critical appraisal. This has been made possible by the unique design of the main plant which affords two completely independent halves that are mirror images of each other. This design will allow a new process development to be contrasted with the present standard operation on a simultaneous basis, at high tonnage rates and on the exact same ore conditions. This feature is expected to yield improvements in recovery and efficiency not otherwise obtainable.

Arizona Section
A. I. M. E.
Spring Open Pit Meeting
Duval Sulphur & Potash Company
Tucson, Arizona
May 22, 1959

Chairman: Ben G. Messer, Assistant Resident Manager

TIME TABLE:

9:00-9:30 a.m. - Registration at Engineering Office.

9:30 a.m. - General Tour of Mine.

11:00 a.m. - General Tour of Mill (for those who wish to visit the mill).

12:00 noon - Lunch at General Office.

2:30 p.m. - Technical Session at El Conquistador Hotel, East Broadway, Tucson, Turquoise Room.

Papers:

1. - "Prospect Drilling, Sampling and Assaying Procedures and Observations at Esperanza." by Ben G. Messer - Duval Sulphur & Potash Company, Copper Division.

2. - "Relative Reliability of Rotary Drill Sampling against Churn Drill Sampling" by G. E. Knapp, Engineer, Copper Cities Division of Miami Copper Company.

3. - "College of Mines, University of Arizona" by Dr. J. R. Forrester, Dean of College of Mines, University of Arizona.

General Discussion.

6:00 p.m. - Cocktails - Turquoise Room, El Conquistador Hotel

7:00 p.m. - Dinner - same as above. Duval Sulphur & Potash Company - host.

N.B. - Cocktail hour and dinner are stag.

GENERAL INFORMATION ESPERANZA PIT:

Prospect drilling started - May, 1955.
Plant construction started - June, 1957.
Mine development started - November, 1957.
Ore production started - March, 1959.
Present ore production rate - 11,000 tons per day.
Present waste production rate - 30,000 tons per day. Will soon drop to a 1 to 1 ratio.
Mining under contract to Isbell Construction Company of Reno, Nevada.

The ore body lies chiefly in three types of rocks; (1) a clastic series composed largely of graywacke, arkose and conglomerate - breccia, (2) an intrusive andesite and, (3) a quartz monzonite porphyry. The known ore lies in an enriched blanket averaging about 130 ft. in thickness covered by an average of 95 ft. of overburden.

To date, about 8,600,000 tons of waste have been moved and about 740,000 tons of ore milled. Bench heights are 35 feet with 0.5 to 1 slopes. Blast hole drills are 9 inch, drilled with rotary machines. Blasting is done with ammonium nitrate - fuel oil mixture. Haulage is by trucks over an average haul of 1.4 miles for ore and about 1/2 mile for waste.

Esperanza

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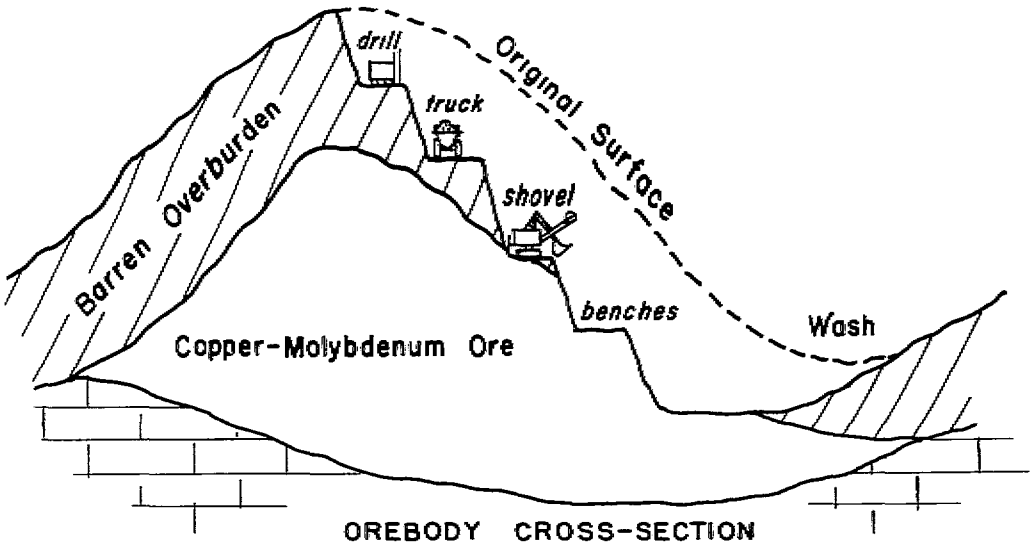
of 1957 to remove 6 million tons of barren overburden to expose enough of the ore body so that routine bench mining could proceed. Both stripping and construction were completed by late February of 1959 and the first ore was fed into the process equipment.

Mining Practice

The ore body as outlined by the drilling program is roughly contained in a Sierrita Mountain foothill which is some 350 feet high and 4,000 feet long. The mineralized section is covered by a blanket of barren overburden varying in thickness and averaging around 100 feet.



OREBODY CROSS-SECTION

The mining practice is the standard bench operation typical of open pit mines. Blast holes are drilled along the bench face and loaded with ammonium nitrate explosive. After detonation, the shot-down face is loaded with 5 cubic yard electric shovels into 40-ton diesel trucks.

The nature of the deposit is such that waste rock must be continually removed to expose fresh ore for mining. The ratio of waste removed to ore mined, generally referred to as the stripping ratio, will average about 1 to 1 over the life of the ore body. Thus, for the daily 12,000 tons of ore hauled to the concentrator, a like tonnage of waste goes to the dump.

Careful assaying, mapping and mine planning are necessary to assure continuous daily production of ore, a low stripping ratio and a minimum loss of ore values to waste.

Milling Practice

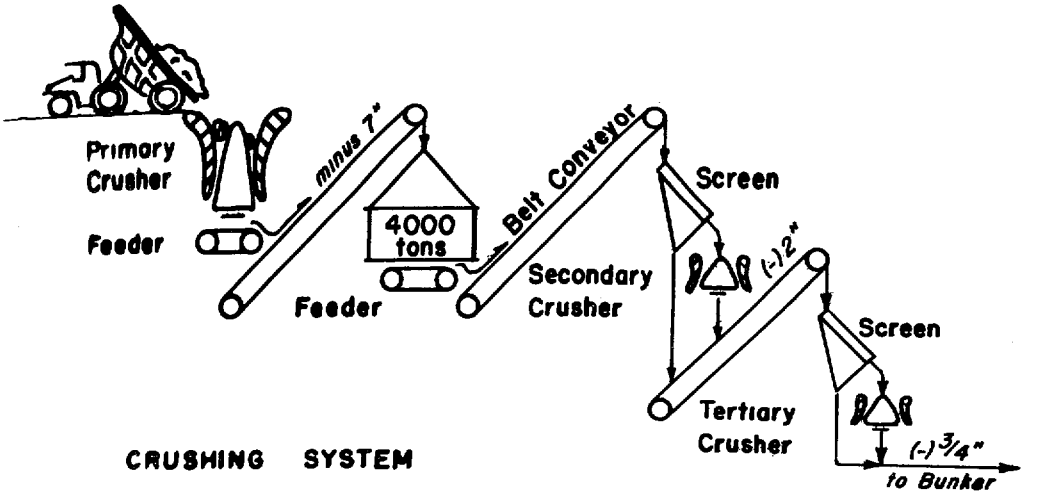
A. Crushing

Mine run ore contains finely disseminated crystals of the black copper sulfide mineral chalcocite along with lesser percentages of the so-called

oxide minerals of copper. Total copper concentration in the ore averages less than one percent. Also present in addition to the copper minerals, is a significant quantity of the molybdenum sulfide mineral called molybdenite. Molybdenum metal concentration is expected to average 0.022% throughout the ore body.

The first refining problem is size reduction to unlock the mineral crystals from the mother rock and to reduce such crystals to dimenions suitable for flotation.

The mining method produces broken rock up to 4 feet in size. Primary crushing of this material is done by the 48 inches gyratory crusher which is housed in its seven-story building.



CRUSHING SYSTEM

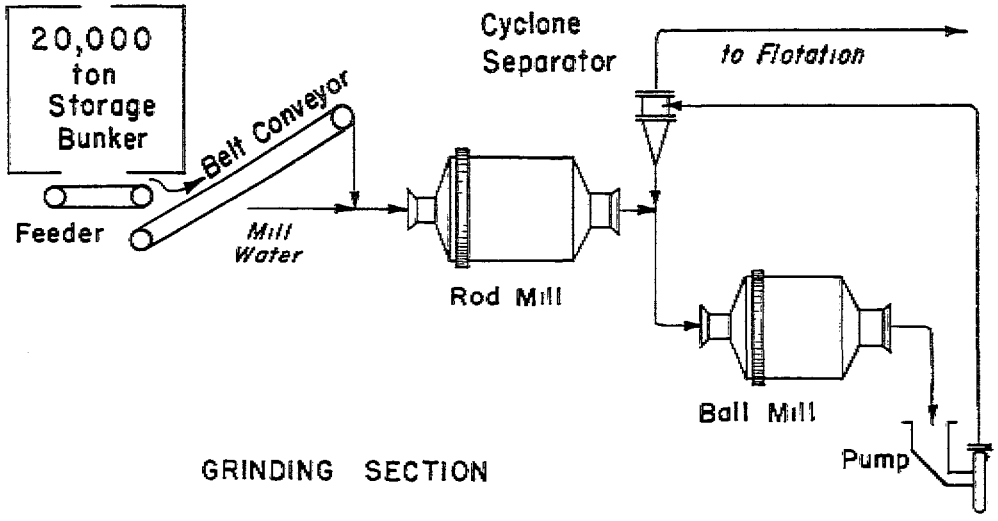
The primary crusher reduces the ore to a maximum size of 7 inches. Further size reduction is carried out in two stages by similar gyratory crushing machines of smaller size. Dry crushing ultimately reduces the particle size to less than 3/4 inch. This material is transferred by belt conveyors to the 20,000-ton storage bunker at the head of the concentrator.

Throughout the crushing system dust collectors are used at all crushing and transfer points to prevent loss of fines and eliminate a serious housekeeping problem.

Electronic instrumentation has been used throughout the system to provide maximum capacity without overload.

B. Grinding

Further size reduction to less than 1/100 of an inch is accomplished in large wet grinding mills. Crushed ore from the 20,000-ton storage bunker is fed to two of the worlds largest rod mills at the rate of 250 tons per hour each. Sufficient water is added with the feed to give the resulting pulp fluidity and the desired pulp density or percent solids.



GRINDING SECTION

The rod mill discharge is split to two ball mills wherein further and final size reduction is accomplished. The ball mill discharge is pumped with a slurry pump to the primary cyclone separators. These devices make a size classification and send the ore of desired fine size forward to flotation and return any oversize back to the ball mills.

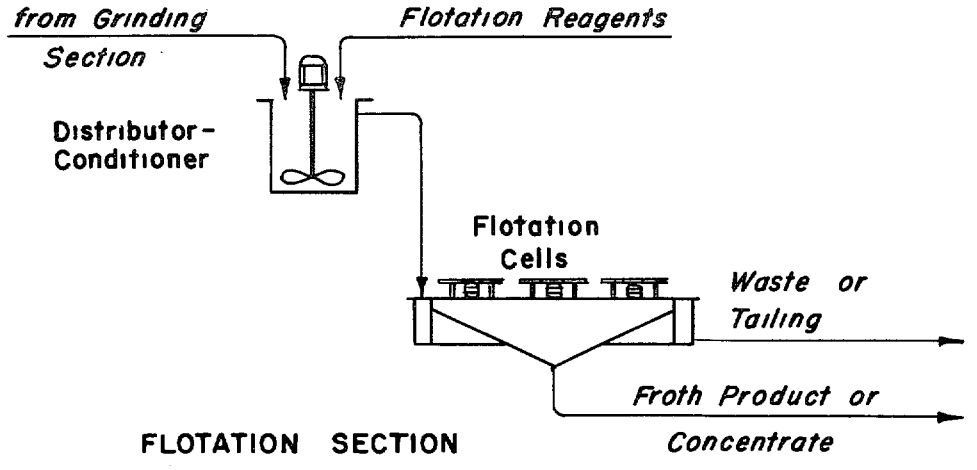
These grinding mills have outside diameters of thirteen feet three inches. The rod mills are sixteen feet long and each is charged with 130 tons of steel rods. The ball mills each carry 150 tons of steel balls. These tonnages of grinding media are maintained by periodic additions equal to the weight of metal which is worn away in the grinding of the ore. The recharging averages some eight tons of steel per day and is one of the major costs in the milling operation.

Here again in the grinding section the use of recording and control instrumentation is evident. These sensitive instruments keep a constant vigil on each phase of the section to assure maximum efficiency and reliability.

C. Flotation

Having accomplished the desired size reduction, next begins the important task of separating the valuable minerals from the mother rock.

The primary cyclone discharge enters the distributor-conditioners where the flotation reagents are added. These reagents, ignoring the gangue rock, selectively seek out the valuable minerals and are adsorbed on their surfaces. Once adsorbed they effectively resurface the mineral and alter the surface characteristics to one having a water repellent, air-loving nature.



FLOTATION SECTION

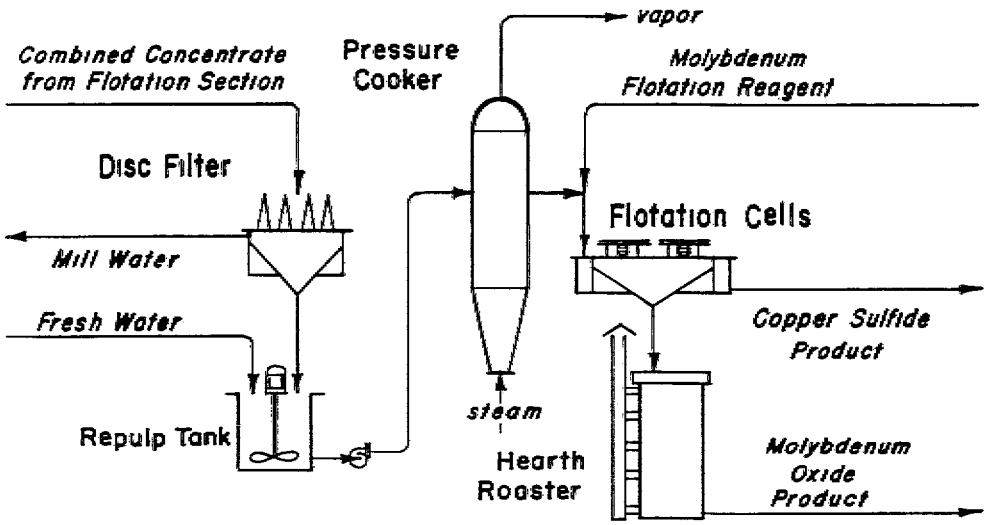
From the conditioner-distributor the reagentized slurry enters the long trough-like flotation cells. The cells provide agitation such that the mineral particles are gently suspended in the water carrying medium. Air is introduced into each cell below the agitator resulting in a multitude of small bubbles rising through the suspended slurry. The reagentized minerals are attracted to the bubbles and floated to the surface of the cell. Additional reagents are added to provide a stable froth on the cell surface wherein the floated mineral collects and overflows the cell lip. Additional flotation steps are required to further refine the flotation product to the desired chemical purity.

The mother rock, unaffected by the action of flotation, moves from cell to cell down the series and ultimately discharges out the bottom of the last cell in the row.

D. Molybdenum Recovery

Both of the principal products, copper and molybdenum, plus a trace of silver are concentrated in the flotation product. The problem of separating molybdenum is one of destroying the reagents used initially to make the copper-molybdenum minerals float and then reconditioning for specific molybdenum flotation.

This is accomplished by first filtering the reagent contaminated mill water from the combined concentrate and repulping with fresh water. The resulting slurry is fed to a giant pressure cooker wherein the reagents coating the minerals are distilled away. To the then sterile pulp is added a collector selective for molybdenum and flotation is again conducted. The froth product from this step is the molybdenum sulfide, while the tailing is the final copper product.



MOLYBDENUM RECOVERY SECTION

The molybdenum sulfide concentrate is then fed to the ten-hearth roaster where it is oxidized to the oxide form for sale to the metals trade.

E. Copper Concentrate Shipment

The final copper concentrate, the unfloated mineral from the molybdenum flotation section, is filtered and conveyed by belt conveyor to the storage house adjacent to the mill building.

Each day the accumulated tonnage is weighed into trucks for transport to the railhead some eleven miles away from the plant. At the siding the trucks dump into open gondolas for shipment to the custom smelter.

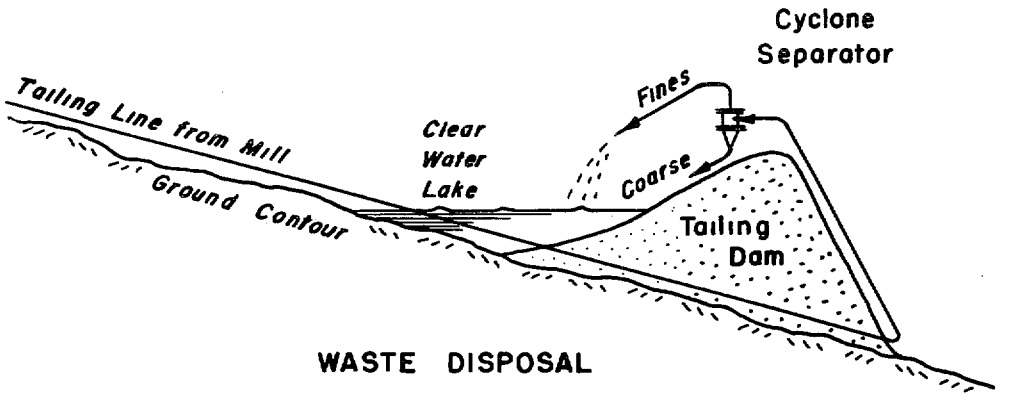
This concentrate, sold as such to the smelter, contains between 25 and 35 percent copper and three to four ounces of recoverable silver per ton.

F. Gangue Tailing Disposal

The mother rock waste leaving the plant presents the dual problem of ultimate disposal and water reclamation.

The magnitude of the disposal problem can be appreciated when one considers that nearly the entire 12,000 tons per day of finely ground plant feed must be disposed of every day for the life of the property. Obvious too, is the fact that if the water used to transport this waste away from the immediate vicinity could be salvaged for reuse, a tremendous saving in both money and a precious natural resource would result.

An adroit solution to these problems has evolved through the years.



WASTE DISPOSAL

In essence, it takes advantage of a gravity flow tailing line to provide feed to the tailing cyclones. The cyclones discharge their relatively course underflow on the top of the growing dam and there compact. The relatively fine, clayey overflow discharges inside the dam. The fines settle out making a water tight seal against the dam and the clear water forms in a back lake for reuse in the milling process.

Instrumentation

Various types of industrial instrumentation have been used throughout the entire processing facility. Where ever possible the tasks of operating personnel have been replaced by electronic-pneumatic recording and control devices. In addition to providing process records for metallurgical study, these controlling instruments sense process upsets imperceptible to human beings and constantly react to maintain desired equilibrium. In this manner the duties of the operating personnel have been largely reduced to that of an attendant. Each section of the plant has a central station where both power and process controls have been assembled in consoles and graphic panels. In this manner the scope of each operator is expanded without sacrifice of either efficiency or reliability.

One example of applied instrumentation is in the operation of the water field system. Water wells are located some six miles from the plant proper. Level control devices at the plant sense the process need for more or less fresh water. An automatic control signal is sent by radio to the water field where unattended pumps correct for the need.

Another example of the use of automatic control is in the molybdenum recovery section. Here a combination of flow, density, level, pressure and temperature measurements are integrated to maintain the desired metallurgical condition in the pressure cooker. The attendant operator functions only when process upsets and mechanical failures are beyond the range of the control devices. In such an event both light and sound alarms function to alert the operator.

Exploration

The Copper Division conducts an intensive exploration program to augment the metallic mineral reserves of the company. Scouting personnel are on constant alert for areas and properties worthy of field party reconnaissance. Property evaluations are made by an exploration team that includes geologists and mining engineers. Advantage is taken of the most recent advances in methods, equipment and geochemistry.

Research

Modern laboratory facilities are equipped not only for routine analysis and process control, but also for research in the mineral dressing field. Those studies that apply directly to copper metallurgy can be transferred from laboratory scale directly into the plant for critical appraisal. This has been made possible by the unique design of the main plant which affords two completely independent halves that are mirror images of each other. This design will allow a new process development to be contrasted with the present standard operation on a simultaneous basis, at high tonnage rates and on the exact same ore conditions. This feature is expected to yield improvements in recovery and efficiency not otherwise obtainable.

Relative Reliability of Rotary Drill Sampling Against Churn Drill Sampling

By G. E. Napp

When asked to prepare a paper on Churn Drill and Rotary Drill sampling, it was felt the best we could do in the time available, was to match the assays achieved by the two methods, against our mill heads and corrected grade. The churn drill assays were examined over the first two years of Copper Cities production and the Rotary's over the following two years. Both types of drills were drilling nine inch holes in similar ground. The Mine grade was 7.44% higher during the first two years.

Churn drill blast hole drilling terminated at Copper Cities in August, 1956. The machines were equipped with a dump box and a splitter, which took a 1/12 cut out of each bailing by means of a single slot in the bottom of the launder. When the hole was down to grade, this retained 1/12 fraction was then cut in a Jones splitter to approximately one gallon of sludge.

A 40-R Bucyrus Erie Rotary Drill was put into service in August, 1956. This drill utilizes a 600 CFM single stage compressor, at 35 lbs. pressure for cleaning holes. A wedge shaped container is used to catch the sample. The narrow end of the can is placed normal to the hole casing so as to catch a representative portion of the hole cuttings. The container is 12" high, $2\frac{1}{4}$" in width at the small end, 10" at the wide end, and each leg is $24\frac{1}{2}$" long. This sample is also pulled at grade and cut to size in a Jones splitter.

To arrive at a mine grade, the average of the blast hole assays in each shot is applied against the tonnage mined from that shot. A blast hole assay represents about 4,000 tons of material.

The mill heads are obtained by taking a manual sample of the Ball Mill feed every 30 minutes at each mill. These samples are combined at the end of the shift for a shift assay.

A corrected grade is calculated by adding the pounds of copper lost in the tailings to the gross pounds of copper credited to us by the smelter. This is divided by the pounds of dry mill feed. An automatic sampler is used for the tailings sample.

The following chart shows the results of our investigation:

Per Cent Variation of Mine Grade against Mill Heads and Corrected Grade

Churn Drill Sampling

	Mill Heads	Corrected Grade
August, 1954 - July, 1955	-1.22%	-1.93
August, 1955 - July, 1956	+0.88	-0.75
Assay Average for the 2 years	-0.12	-1.35

Rotary Drill Sampling

August, 1956 - July, 1957	+3.68	-0.52
August, 1957 - July, 1958	+2.52	+1.53
Assay Average for the 2 years	+3.04	+0.54

Mr. J. J. Spencer presented a paper, ORE SAMPLING AT CASTLE DOME, at the Arizona Section AIME meeting in 1951. This paper was later published in the April 1951 issue of Mining Engineering. For one phase of this paper, tests were run comparing flat valve and dart valve bailers. The reason for this test was to check the possibility of values being shaken to the bottom of the hole through the bumping of the tools: In 16 holes, the flat valve assays averaged 9% more than the dart valve assays. These holes were in a disseminated chalcocite area. In 19 holes, drilled in a disseminated chalcopyrite area, the flat valve assays were 2% less. Evidently, some assays values were being lost in the bottom of the hole in the chalcocite areas. The ability of a Rotary Drill to blow a hole clean could be a partial explanation of the Rotary assays running higher than those of the Churn Drills.

Prospect Drilling, Sampling and Assaying Procedures and Observations at Esperanza

by B. G. Messer
Duval Sulphur & Potash Company, Copper Division

After Duval Sulphur & Potash Company had gained control of the land necessary to proceed with a prospect drilling program now covering the Esperanza Pit, Dr. Harrison A. Schmitt, our consultant mining geologist, started mapping the area on a 1000 feet to the inch "blow-up" of a U.S.G.S. quadrangle sheet. After several days of such work, Dr. Schmitt drew an oval on the map with an orange-colored pencil and said, "The orebody should lie within this oval. I don't know whether it will average 0.3% or 1.00% copper." This oval now covers the Esperanza orebody with very minor exceptions.

Since we were desirous of obtaining the most accurate data possible, Dr. Schmitt selected a 500-foot interval drilling pattern of equilateral design. Thus, each hole would be equidistant from every other hole, and all would carry equal assay influence. Similarly, if a close pattern became necessary, then the intermediate holes would be on a 250-foot equilateral spacing. Such a drilling pattern would give the most uniform and representative results. It also allowed an easy method of determining "running" results of the drilling for estimating ore tonnage and grade. A standard tons per vertical foot of hole was used based on the hexagonal area of influence of a hole. As the pattern expanded, each addition to the orebody was simple.

The centerline of the old New Year's Eve Mine shaft was arbitrarily selected as an origin for setting up the grid and coordinate system. This would also allow the shaft to serve as one sample point in the system. The necessary survey control was established and marking on the ground of some of the 500-foot equilaterals begun. This was expanded as necessary.

It was decided to begin drilling with one churn drill and one diamond drill at points on the pattern about 1800 feet apart. Both holes pierced the ore zone and the drilling program accelerated. At the peak of this program there were three churn drills and three diamond drills in operation two shifts per day six days a week. Since the churn drill was considered to give the more accurate sampling, it was used on the expanding grid pattern and to fill in between known ore holes. The diamond drills were used mainly for advance geological and assay information over the entire area. Diamond drill holes were eventually drilled to delete ore possibilities in areas selected for waste dumps, tailing disposal and mill site. Only 7 diamond drill holes lie within the ore zone as compared to 36 churn drill holes.

CHURN DRILLING PROCEDURE

Churn drill holes were started at a nominal 12-inch diameter and not allowed to finish at less than a 6-inch diameter except in a very few cases in the deeper holes. The holes were cased or liners used of standard seamless API pipe with welded joints. At no time was the end of the tool string out of the casing so that it could whip the hole wall. Each 5-foot run was sampled.

The drilling sludge was bailed from the hole using a short dart bailer of a diameter not less than 2-inches in diameter less than the casing in which it was used. A minimum of four bailing trips per sample was standard, but usually several more were made to thoroughly clean out the cuttings.

Churn Drilling Procedure (con'd.)

The cuttings were dumped in a nearby splash-proof dump box and then passed through a sample splitter into a sample tub. The drill tools and bailer were washed clean at this point. This was split again, if large in volume, until about a 3-gallon sample went to the sample preparation shack.

New drilling water for the next run was added by lowering it into the hole with the bailer so as not to wash the sides, and drilling begun again.

DIAMOND DRILLING PROCEDURE

Diamond drill holes were started at NX core size and completed at no less than AX size with the standard core-drilling machines, solid drill stems. After reaching the ore zone, the "M" series core barrel of the Joy Mfg. Co. was used, thus preventing grinding of the core. This resulted in a good many short runs because of the fractured nature of the ground and increased these drilling costs a great deal. Ten-foot assay runs were general for core tests. All sludges were collected in a three-compartment sludge tank. Two such tanks set at each drill were used alternately for settling of sludges and preventing delay. Holes were washed well between ten-foot runs. These sludge samples were split and sent to the sample preparation shack. All cores were placed in special boxes and saved.

SAMPLE PREPARATION AND ASSAYING

Cores were split and the half crushed and a split taken for assaying.

The sludge samples were dried on a butane-fired steam table. The dried sample was pulverized and split for assay purposes. Four small samples were taken - two going to Assay Offices, one filed, and one used by the geologists for study.

At the churn drill holes the sampler prepared by panning with a gold pan two small sacks of material, one of the coarser cuttings and one of the mineral concentrate for study. Sample boards were prepared whereon some of these cuttings were glued side by side giving a relatively good picture of the hole.

Assays for copper were made by two assay offices, one a wet determination, the other electrolytic. The electrolytic assay was taken as final for use in ore estimates. Assays for molybdenum were made by our own assayers.

All cores and samples of all sludges, diamond or churn drilling, have been saved and stored.

SAMPLE CHECKING

Two areas were selected within the ore zone, wherein the 250-foot intervals were drilled and results compared. The average hole assays in each case were about 10% low, however, the ore columns averaged more in height so that the assay units checked within 1%. This could have been chance. However, if final selectivity of mining was considered, an accurate check resulted.

Sample Checking (Con'd.)

To further check sampling methods and results, to check ore continuity between holes, and to furnish material for metallurgical tests, an adit was driven into the orebody and crosscuts made to two churn and two diamond drill holes. These holes were raised on to the top of the ore and a winze taken to the bottom of the ore on two of them.

Each round blasted was crushed separately, automatically sampled and assayed. Results indicated that diamond drill hole assays were about 5% high and churn drill holes about 4% low as compared to the bulk sampling.

This underground work proved continuity to the orebody and that our sampling procedure by drilling was essentially correct.

GENERAL

Following is a table of total footages drilled:

34 diamond drill holes	-	12,376 feet
49 churn drill holes	-	17,093 feet
83 total		29,469 feet

Average cost of each:

Diamond drill holes	- $12.06 per ft.
Churn drill holes	- $11.91 per ft.

In general, the ground was quite broken and hard to diamond drill. Core recovery was around 88% in the ore zone. Some areas were quite siliceous and caused slow churn drilling with lots of bit wear. Analysis of zones between setting of the churn drill casing liners showed no salting of samples.

Drilling efficiencies were on the average for diamond drilling of 11.3 ft. per shift, and for churn drilling, 10.3 ft. per shift.

Assays of diamond drill sludges were about 10% higher than core assays. This was expected because the seams in the orebody are mineralized, and in drilling these parted causing some loss of mineral from the core to the sludge.

Within the orebody there were 7 diamond drill holes and 36 churn drill holes in ore.

The assay value of the first eight holes drilled were very close to the final grade accepted for the orebody. Also averages of the alternate line of drill holes checked each other. Only two holes within the ore zone showed abnormally low assays, but they were not blank.

Since there were no blank holes within the orebody and check results made were good, it was decided that the 500-ft. drilling pattern was adequate to determine a commercial orebody of approximately 50,000,000 tons averaging 0.7% copper and 0.02% molybdenum. A study of results were made by Dr. Schmitt and by Ira Joralemon with the same conclusions.