DEPARTMENT OF MINERAL RESOURCES
STATE OF ARIZONA

OWNERS MINE REPORT

Date July 10, 1939

1. Mine Christmas
2. Mining District & County Banner
3. Former name Christmas
4. Location Gila County, Arizona, on State Highway 77, 9 miles north of Winkelman.
5. Owner Christmas Copper Corporation
6. Address (Owner) Beverly Farms, Mass.
7. Operator Above 400 level leased to: C. B. Hanraty
8. Address (Operator) Christmas, via Winkelman, Ariz.
9. President F. P. Knight
10. ~~Gen.-Mgr.~~ Vice-Pres. in charge: F. P. Knight, Jr.
11. Mine Supt. C. B. Hanraty
12. Mill Supt. S. Knight
13. Principal Metals Copper, gold, silver
14. Men Employed 30
15. Production Rate Capacity 500 tons per day
    Present lease 90 " " "
16. Mill: Type & Cap. Floation, 500 tons.
17. Power: Amt. & Type 1800 H.P. 4 Benz Diesels.
18. Operations: Present Lessee limited to 100 tons per day of lime, fluxing ore for the Hayden smelter. Company doing small amount of development at the 770 level; also supplying capacity output of power to the San Carlos Irrigation Project.
19. Operations Planned Additional capital being sought, with which to open up the higher grade ore inthe lower levels and resume profitable mill operation and production of concentrates.
20. Number Claims, Title, etc. 37 Patented - 553 acres.
    45 Unpatented
    Owned by Christmas Copper Corporation
21. Description: Topography & Geography The Christmas property is 103 miles east of Phoenix and 78 miles north of Tucson. It covers a valley on the east slope and at the south end of the Dripping Spring Mountains, terminating to the east at the mouth of the valley, at the Gila River; and including parts of Sections 19,20,21,28,29,30 of T4S, R 16 E, and of Sec. 25 of T4S, R 15 E.
22. Mine Workings: Amt. & Condition The mine is operated through a main (No.3) shaft, 908 feet deep, and a haulage tunnel connecting at the 400 level of that shaft. Levels are opened at approximately 100, 200, 300, 400, 635 and 770 feet. Four other shafts help supply ventilation. A shaft was started for exploration east of a major fault and reached a depth of 518 feet. Of a total of approximately 10 miles of workings, about 40% is of actual or potential use.

(over)

23. Geology & Mineralization — Ore in contact metamorphic ir ther flat limestone beds near the margin of intruded diorit orphyry. Beds are from a few feet to 68 feet thick with shale strata and porphyry sills between. Ore has average width of 80 feet from porphyry contact with maximum width of about 170 feet, and has unusual continuity and uniformity for long distances. Known thickness of over 1000-ft. of Carboniferous and Devonian limestones. Of over 10,000 ft. of contact, 4,000 ft. explored.

24. Ore: Positive & Probable, Ore Dumps, Tailings — 440,000 tons 3+ % copper
Reasonable expectancy of 3,000,000 tons and possibly much more.

24-A Vein Width, Length, Value, etc.

25. Mine, Mill Equipment & Flow Sheet — Mine: Hoists, compressors, pumps, shops, etc. sufficient for production of 700 tons per day.
Mill: Bins, crushers, ball mills, flotation cells, thickener, filter plant; capacity 500 tons per day.
Flow Sheet: Ore through 400 haulage (storage battery loco.) to mill or smelting ore bins. Smelting ore trucked 3/4 mi. to R.R. Mill ore crushed, floated: Concentrates by gravity to filter plant at R.R.

26. Road Conditions, Route — Christmas is shown on Arizona road maps. Dirt road from Oracle Jct. is dusty. Dirt road from Florence through Kelvin is good and little traveled. Dirt road from Jct. outside Globe is OK little traveled, mountainous but with good grades.

27. Water Supply — 30,000 gals. per day from Mine. Other needs from wells on company claims adjacent to Gila River.

28. Brief History — Property located about 1880. 1883 until 1902 mining on Indian reservation prohibited. 1902 to 1907 Saddle Mountain Mining Co. smelted at the mine 113,322 tons averaging 2.4% copper. 1908 to 1925 Gila Copper Sulphide Co. was owner, and from 1916 to 1921, 410,810 tons averaging 2.8% copper were shipped to the Hayden smelter. 1925 to date, present owners in control and have shipped 591,463 tons averaging 2.18% of which 321,075 tons averaging 2.01% were milled in 1929 - 31. Total production of record to Jan 1, 1939 is 1,115,645 tons with net yield of 45,218,269 lbs of copper. Practically all of this ore came from above the 400 level.

29. Special Problems, Reports Filed — Statement regarding certain conditions and prospects of the Christmas Mine: Appraisal by George A. Packard, Mining Engineer, Boston, Mass.
Reports by Guy N. Bjorge; Harrison Schmitt; Burch, Caetani and Hershey; and others are available.

30. Remarks — The company in 1936 was able to finance dewatering, retimbering No. 3 shaft, and general reconditioning. It has not been able to finance work necessary for extraction of mill tonnage of the higher grade, better than 3%, ore discovered in the lower levels prior to shut down in 1931. The company is confident that with such financing it can produce copper under present conditions for 8¢ per lb.

31. If property for sale: Price, terms and address to negotiate.
Address: Christmas Copper Corp.,
Beverly Farms, Mass.

ATTACHED:
Statement Regarding Certain Conditions and Prospects of the Christmas Mine.
Appraisal of the Property of the Christman Copper Co. by Geo. A. Packard, M. E.

32. Signed F. P. Knight, Jr.
Vice Pres.

33. Use additional sheets if necessary.

Mc 19

DEPARTMENT OF MINERAL RESOURCES
STATE OF ARIZONA
OWNERS MINE REPORT

Date July 10, 1939

Mine Christmas

District Banner

Location Gila County, Arizona, on State Highway 77, 9 miles north of Winkelman.

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Operator Above 400 level leased to: C. B. Hanraty

Address Christmas, via Winkelman, Ariz.

President F. P. Knight

Gen. Mgr. Vice-Pres. in charge: F.P.Knight, Jr.

Mine Supt. C. B. Hanraty

Mill Supt. S. Knight

Principal Metals Copper, gold, silver

Men Employed 30

Production Rate Capacity 500 tons per day
Present lease 90 " " "

Mill: Type & Cap. Flotation. 500 tons.

Power: Amt. & Type 1800 H.P. 4 Benz Diesels.

Operations: Present Lessee limited to 100 tons per day of lime, fluxing ore for the Hayden smelter. Company doing small amount of development at the 770 level; also supplying capacity output of power to the San Carlos Irrigation Project.

Operations Planned Additional capital being sought, with which to open up the higher grade ore in the lower levels and resume profitable mill operation and production of concentrates.

Number Claims, Title, etc. 37 Patented - 553 acres.
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Description: Topog. & Geog. The Christmas property is 103 miles each of Phoenix and 78 miles north of Tucson. It covers a valley on the east slope and at the south end of the Dripping Spring Mountains, terminating to the east at the mouth of the valley, at the Gila River, and including parts of Sections 19, 20,21,28,29,30 of T4S, R 16 E, and of Sec. 25 of T4S, R 15 E.

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(over)

Geology & Mineralization Ore in contact metamorphic in rather flat limestone beds near the margin of intruded diorite porphyry. Beds are from a few feet to 68 feet thick with shale strata and porphyry sills between. Ore has average width of 80 feet from porphyry contact with maximum width of about 170 feet, and has unusual continuity and uniformity for long distances. Known thickness of over 1000-feet of Carboniferous and Devonian limestones. Of over 10,000 ft. of contact, 4,000 ft. explored.

Ore: Positive & Probable, Ore Dumps, Tailings 440,000 tons 3½ % copper
Reasonable expectancy of 3,000,000 tons and possibly much more.

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Signed F. P. KNIGHT, JR.,
Vice Pres.

Use additional sheets if necessary.

DC hwy

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STATE OF ARIZONA
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Men Employed 30

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Signed.....
Vice Pres.

Use additional sheets if necessary.

MC-19

DEPARTMENT OF MINERAL RESOURCES
STATE OF ARIZONA
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Mine-Christmas

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Operator - Above 400 level leased to C. B. Hanraty

Address - Christmas, via Winkelman, Arizona

President - F. P. Knight

Vice-Pres. in charge:- F. P. Knight, Jr.

Mine Supt. - C. B. Hanraty

Mill Supt. - S. Knight

Principal Metals - Copper, gold, silver

Men Employed - 30

Production Rate - Capacity 500 tons per day
Present lease 90 tons per day

Mill: Type & Cap. - Flotation. 500 tons.

Power: Amt. & Type - 1800 HP. 4 Benz Diesels

Operations: Present - Lessee limited to 100 tons per day of lime, fluxing ore for the Hayden smelter. Company doing small amount of development at the 770 level; also supplying capacity output of power to the San Carlos Irrigation Project.

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SIGNED - F. P. Knight, Jr., Vice-Pres.

OC
MC 19

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Signed F. P. Knight Jr.
Vice Pres.

Use additional sheets if necessary.

GEORGE A. PACKARD
Mining Engineer
50 Congress Street, Boston, Mass., U. S. A.
Cable Address, Geopack, Boston

APPRAISAL OF THE PROPERTY OF THE

CHRISTMAS COPPER COMPANY

GILA COUNTY, ARIZONA

By George A. Packard

October 1, 1934.

This statement is based on a thorough examination by myself of the Christmas property above the 500-level made in 1919, followed by a number of visits up to 1929, and on the reports of Guy Bjorge, geologist, and J. A. Thomas, superintendent, subsequent to that date.

CHRISTMAS COPPER COMPANY

APPRAISAL

552.731 acres of patented land at (Government price) $5 per acre - - - - - - -		$ 2,763.65
Buildings, machinery, equipment, as per list and auditor's report, with depreciation allowance		552,323.55
Development, not including abandoned and useless workings:		
Christmas, Hackberry, Shamrock, and No. 2 shafts - 670 ft. at $50 a foot - - - - -	$33,500.	
No. 3 and No. 4 shafts, 1426½ ft. at $100. a foot - - - - - -	142,650.	
Drifts, crosscuts and raises 20,681 ft. at $8 a foot - - - - - - - -	165,448.	341,598.00
Proven ore, as per report of J. A. Thomas of June 1931, including only the ore averaging 3.18% copper on the 600 and 800 levels 23,500 tons at $1. - - - - - - - - - - - - - - - - - -		23,500.00
Total proven value - -		$920,185.20

In addition to this, based on past production of 5000 tons for each foot of thickness in favorable beds, there is indicated in the beds opened in drifts 604, 804, 819A and shaft, with a total thickness of 88 feet, - 440,000 tons having a potential net value of $1. a ton - - - - - - - - - - - - - - - - - $440,000.00

And as explained under the headings of Geology, and Ore Reserves, based on past production of 250 tons per foot of contact explored to date from beds aggregating only 200 feet in thickness, there is in the remaining 6000 to 10,000 feet of contact on both sides of the Christmas Fault, and in the unexplored lower, elsewhere more favorable, beds, a reasonable expectancy of 3,000,000 tons, and possibly much more ore of equal or higher grade.

Dated: Boston, Massachusetts
October 1, 1934

Geo. A. Packard

GENERAL INFORMATION:

The Christmas Mine is 103 miles east of Phoenix, on the Arizona Eastern Railroad, and 10 miles from the Hayden Smelter of the American Smelting and Refining Company. It lies on the north bank of the Gila River. The main shaft is at an elevation of 3100 feet. From the bins at this shaft there is a wire-rope tramway 7300 feet long to the loading bins at the railroad 950 feet lower.

The mine furnishes less than 30 gallons of water per min., but water for milling purposes is obtained from wells near the river. Timber, of which little is required, must be brought in from outside. Power has been developed by Diesel engines at the mine, but may be obtained in the future from the Coolidge Dam. During the last year of operation (1930-31) three hundred men were employed at the property. The employees live near the mine where the Company owns more than one hundred buildings, including store, club-house, school and dwellings, with a water-supply system.

EQUIPMENT:

The mine is equipped with a power plant having a total capacity of 1800 horse-power. There are hoists, compressors, pumps, bins, a crusher, and sorting plant, and change house, all sufficient for a production of 700 tons per day, details of which are given in a list filed herewith.

The tramway to the railroad has a capacity of 1000 tons per 24 hours. There is a flotation mill built by the Southwestern Engineering Company in 1929, which treated an av-

erage of 540 tons per day during the last year of operation.

HISTORY:

The property was originally located in 1883 and was operated by the Saddle Mountain Mining Company until 1907, the ore being smelted at the mine. They treated 113,322 tons of ore averaging 2.45% copper. In 1909 it was taken over by the Gila Copper Sulphide Company. Up to the time of my examination in 1919 they had shipped 300,389 tons averaging 2.89% copper. From that time until work was suspended in 1921, and from the time of resumption in 1925 to the end of 1926, production was 161,667 tons. All of the Gila Company production was sold to the smelter at Hayden. At the end of 1926 the property was acquired by the Christmas Copper Company, which has produced 506,200 tons. Of this 321,075 tons was concentrated, the balance shipped direct to the smelter. The total production to date is reported as 1,081,578 tons, with a net yield of 45,500,000 pounds of refined copper, after mill losses and smelter deductions.

METHOD AND COSTS OF OPERATION:

The mine is operated through a main shaft (No. 3) 908½ feet deep, and a tunnel connecting at the 400 level of the same. There are levels opened at approximately 100, 200, 300, 400, 500, 600 and 800 feet. Four other shafts help supply ventilation. A new shaft (No. 4) is being sunk

on the New York claim for the exploration of the ore bodies east of the fault referred to later, and for the development of the lower levels to the west. This has reached a depth of 518 feet. Direct smelting ore is hoisted to the surface at No. 3 shaft and sent to the railroad bins over the tramway. Mill ore is delivered through transfer raises to the No. 4 level haulage-way. Ore from below that level is hoisted to the 300 and delivered to chutes to the 400.

Mining costs, exclusive of depreciation and depletion for the last year of operation (May 1, 1930 to May 1, 1931) are reported as $2.047 per ton, distributed as shown on the attached sheet, page 16.

Because of its lime and iron content, this ore has always been in demand for fluxing purposes at the smelter, and prior to 1929 all ore was direct smelted, a total of 651,000 tons. On this smelting ore the recent railroad freight has been only 31¢ per ton, the smelting charge 50¢ per ton, with a 75¢ bonus for the lime, but no credit for gold and silver.
At present prices the value of these metals would be 42¢ a ton. These freight and smelting charges are remarkably favorable.

The concentrates from the flotation mill are delivered through a pipe to a filtering plant at the railroad. After dewatering, they are shipped to the smelter, in addition to the crude ore which the smelter continues to desire as a flux. Cost of delivering to the mill was 9¢, and milling 55.2¢. The ratio of concentration varied from 14 tons to 1

up to 22 tons to 1.

Based on the above costs, but with adjustment for present wages and gold and silver prices, the management presents an estimate, a copy of which is attached, of expected copper costs of 6.62¢ per pound on ore of 3.18% grade, or of 10.41¢ per pound on the ore of 2% grade. The grade of 3.18% is the average of the lower levels; the 2% the grade anticipated in cleaning up that portion of the upper levels where the better ore was pretty well removed by the American Smelting and Refining Company during the war. These figures are exclusive of depreciation and depletion, but include credit for gold and silver. They also include credits for rent and store profits, without which they would be 6.914¢ and 10.932¢. Depreciation charges bring them up to 6.969¢ and 11.03¢.

As past work is reported as showing 24.3 tons of ore obtained for each foot of development, the figure of $.196 for development appears low. Apparently it should be (at $8 per foot) $.329. This increases per ton costs to $3.987, including depreciation, and copper costs to 7.213¢ per pound on the 3.18% grade (assuming recovery of 55 lbs. per ton) and 11.456¢ on the 2% grade of ore. With the price of copper at 9¢, the ore on the lower levels would net very close to $1 per ton at these figures.

GEOLOGY AND ORE OCCURRENCE:

A good general idea of the surface geology is given by the accompanying property map, and with much more detail for the west half of the property on Bjorge's "Geologic Surface Map" of 1929. These and the two projections show excellently how

the ore occurs in rather flat limestone beds near the margin of intruded diorite porphyry. These beds vary in thickness from 3 to 4 feet up to 68 feet. Each bed has local variations. Between them are shale strata and porphyry sills. Near the porphyry the limestone is partly altered to garnet, and it is this garnetized limestone which makes the ore. Beyond the commercial ore, the limestone is more generally changed to a coarsely crystalline marble.

The ore has an average width of probably 80 feet from the contact with the porphyry, though in places it extends as much as 170 feet, as indicated by the dotted line marked "Limit of Stoping" on Bjorge's map. It has been found, in the favorable beds, along the greater portion of the contact insofar as exploration has gone, approximately 4000 feet. The red line on the property map shows the extent of ore-bearing contact opened to date.

In many places the shale has some copper, - up to 3% in 809 drift on the 800 level. The diorite also carries copper, the average for the Number Four shaft and a diamond drill hole below it, a total depth of 1500 feet, being 0.4%.

The copper occurs as a sulphide, principally chalcopyrite, with some bornite and chalcocite. Near the surface there is considerable oxide ore, and in general there is more oxidation on the south of the porphyry than on the north. The ore is quite uniform in composition. The average analysis for three years prior to my examination in 1919 was-

Gold	.007 oz.
Silver	.27 oz.
Copper	2.62%
Lime	26.0 %
Iron	18.1 %
Insoluble	32.2 %

The ore-bearing geological formations are the Pennsylvanian and Mississippian Limestones of the Lower Carboniferous, here called the Tornado Limestone, and beneath these the Martin Limestone of the Devonian. All of these are favorable formations for copper deposits in the Southwest. The thickness of these limestones, as exposed in the nearby Tornado peak, was measured by Augustus Locke and Guy Bjorge in 1930, and the total (exclusive of the porphyry sills) was estimated at 1330 feet. They placed the lower limit of the mine openings, the shaft then being 850 feet deep, at near the top of the Martin Limestone. As all of the ore mined to date is from above the 500 level, it doubtless came from well above the bottom of the Tornado lime. In his report of June 20, 1931 Bjorge states that most of it is from a thickness of 125 feet on the south and 200 feet of limestones on the north side of the porphyry. As past production exceeds 1,000,000 tons, this gives at least 5000 tons for each foot in thickness of favorable beds.

On the maps will be noted a line marked "Christmas Fault", to the east of which the entire country has been dropped down, possibly 1000 feet or more, and in that part of the property the ore must be sought at that depth. There is considerable minor faulting, as is shown in the accompanying projection of the work south of the porphyry. As correlated by Oscar

Hershey, the Copper Knob bed on the south side is about 180 feet lower than the corresponding outcrop on the north side of the porphyry. If, as seems possible, this is the bed which has been termed the "J Bed" in the stopes south of the porphyry, it is at the lowest point 275 feet below where it was quarried on the north side. All of the beds have a general easterly dip, commonly slight, occasionally up to 35° near faults or the diorite.

The accompanying projections showing the beds and stopes are for the most part fairly accurate sections through the main drifts, but to give a better idea of the continuity, the probable location of promising beds, and the effect of faulting, some workings have been projected which are a considerable distance off the line of section. Two sections only accompany this report. The "Idealized West-East Projection South of No. 3 Shaft" gives a view of the ore-beds mined, and many of the stopes, on the south side of the porphyry. It is of especial value in showing the remarkable continuity of ore in these favorable beds for long distances. If the assumption is correct that the thick ore-body termed "Bed J" in the stopes is the same as the Copper Knob in the old Christmas workings to the east, we have ore more than 40 feet thick, and 40 to 150 feet wide, proven for considerably more than 2000 feet in this bed. Similarly tracing this through the "Northwest-Southeast Projection through No. # 3 Shaft", we have an ore occurrence, broken by the porphyry intrusion, of over 500 feet to the point where this "Bed J" was quarried in the early days.

No section along the north side of the porphyry has been prepared, and many of these old workings are caved, but the "Limit of Stoping" marked on the "Geologic Surface Map" shows a length here of over 1000 feet.

Altogether, there is an aggregate length of contact opened of about 4000 feet. This gives an average yield per foot of contact from the beds mined to date of 250 tons. All of this is west of the Christmas Fault, and there yet remains on this side many hundred feet to explore. The length of the contact to the east exceeds 6000 feet, and Bjorge reports on that side of the Christmas Fault there is more mineralization and a probability of more and better ore.

It will also be seen from the projections that, as previously stated, only a limited thickness at the top of the limestone has been mined. The next 150 feet of beds, underlying those which have been mined down to the 400 level, have not, so far as opened, proven as favorable for mineralization; but in the shaft and on the 600 and 800 levels, and in the little raising which has so far been done between them, other favorable beds have been opened. Reports on this work show, besides the beds on the 500,-

In Drift 601, a mineralized bed 10 feet thick was exposed.

In Drift 604, underlying 601, a bed equal to the height of the drift and extending below it an unknown distance was cut.

In Raise 810A, just as work was stopped the bottom of a similar bed - possibly the same as 604 - was cut. If the same bed, it would be about 24 feet thick.

In the 800 station, another bed, possibly the same as 812 stope, irregular in ore occurrence, is reported.

In 809 Drift - 801, 802, 811 etc. - a shale bed 75 feet thick, continuing 150 feet, carrying considerable copper, is mentioned in several of Thomas's reports.

In 817 - 819A Raise, and 823 is a heavy sulphide bed 28 feet thick.

In No. 3 Shaft, the last 28½ feet was in good ore, and the bottom of the bed not reached.

Channel samples from the beds on these lower levels are reported to average 3.18% copper, and this figure has been used in estimates of future production. From June 6 to July 8, 1931, a shipping test from these beds showed them to be "better than the average of all the ore produced" in the past and yielded as follows, as per smelter statements:

Date 1931	Lot	Tons	% Copper
June 6	298	178	3.20
June 10	299	108	3.35
June 20	300	319	3.20
June 27	301	383	3.50
July 1	302	162	3.00
July 8	303	201	3.20
		1351 tons	Av. 3.27%

Discussing the possibilities of the Tornado and Martin beds, Locke and Bjorge in their report of 1920 stated that: "Arguing from analogy to other districts of Arizona, the lower part should contain more ore". They specified conditions at Globe, Bisbee and Superior to justify this opinion, which Bjorge repeated in 1929 when he said: "The remaining limestones should be more favorable for ore than that already developed."

ORE RESERVES:

Mr. Thomas's report for June 1931, at which time development work was stopped, shows 69,870 tons of "Proven Ore", and 60,700 tons of "Probable Ore", about 10,000 tons of each being classed as "Low Grade". The proven ore, I am told, is that which can be broken by one more round of blasting in the existing stope faces, a most conservative estimate. Obviously, the probable ore would be simply that which could be obtained from a second round. While a little ore has been shipped since that time, apparently the ore conditions remain about the same.

No statement of the copper content of this ore is given, and in making my appraisal I have considered as proven only his tonnage on the 600 and 800 levels which has been channel sampled, and the result of 3.18% copper confirmed by shipment to the smelter of 1351 tons (page 11). As stated on page 6 this will now yield almost exactly $1 per ton profit. To this I have added, as ore indicated in these same beds, based on past production per foot of bed thickness, (page 8), 440,000 tons of the same value.

Records show that there has never been any very large tonnage of ore actually proven on this property, but the continuity of the ore beds, as shown in the projections, while somewhat broken by faults and porphyry tongues, has justified estimates of practically proven and probable ore reserves, based on comparatively limited areas only partially blocked out.

Thus in 1919 I estimated, in beds then exposed near the shaft above the 400 level, practically proven and probable ore equal to 770,000 tons. At that time the ore to the north of the porphyry above this level had been fairly well mined out; but very little ore had been extracted on the south side, though beds H, I, J and K, shown on the accompanying section, had been opened. The production since then, up to date, has been 715,413 tons in this area, and the last mine reports show 75,000 tons proven and probable ore available in these beds, with portions of the contact in the upper horizon not fully explored.

In view of the continuity of these upper beds, as since proven and mined to the east, it is most probable that the beds below them already opened and mined to the northwest, as shown in the projection through the No. 3 shaft, will also be found to the east on the 600 and 800, and below, and yield about the quantity estimated. The approximate elevation at which these beds should occur is shown in the section.

No further tonnage estimate for specific beds had been made, but "Possible Ore" I estimated in 1919 at 3,000,000 tons, with the provision that it might easily be doubled if ore continues along the numerous porphyry tongues. This figure was based on the fact that only about one-fourth of the contact had been explored, and probably little more than half of the favorable beds.

Below the beds already opened are those more favorable limestones referred to under Geology (page 12). More

recently (1932) the property was visited by Mr. Harrison Schmitt, a competent geologist, well known and experienced in the Southwest. His opinion was expressed as follows:

> "Judging from the stratigraphic section at Superior and other places in the Southwest the beds of alternating shale and limestone at Christmas, which contain the ore previously mined, are probably Pennsylvanian in age (upper Tornado) and the massive Mississippian limestone (lower Tornado) and Devonian shale (see U.S.G.S. Bull. 771, p 8) are below. The Mississippian limestone is in general the most favorable ore-bearing bed in the Southwest, but there may be only 500 feet of it at Christmas.
>
> It is my belief that the contact-Metamorphic type of mineralization which gave rise to the ore bodies previously mined has a good chance of extending downward along the boundaries of the diorite and if the Mississippian Limestone is below the present workings possibilities are good for ore bodies larger than those formerly mined."

In view of the past production of 250 tons per foot of contact and 5000 tons for each foot in thickness of the upper favorable beds, and with these most favorable beds unopened west of the Christmas Fault, a considerable length of contact unexplored on that side, and the entire thickness of Carboniferous and Devonian limestones yet to be developed along 6000 feet of contact east of the fault, 3,000,000 tons of possible ore continues to appear extremely reasonable.

Respectfully submitted,

Dated: Boston, Massachusetts

October 1, 1934

Geo. A. Packard

CHRISTMAS MINE

Actual Costs of Mining and Milling for Last Twelve Months' Operation of Concentrator May 1, 1930 to May 1, 1931

Dry tons mined	219,782	
Dry tons milled	189,382	
Dry tons shipped crude	30,400	
	TOTAL	PER DRY TON
Ore extraction	$351,211.64	$1.597
Development	43,077.27	.196
Pumping	2,417.60	.011
Assaying	6,373.68	.029
Aerial tramway	7,252.81	.033
Mine office	9,670.41	.044
General	29,958.18	.137
TOTAL MINING	$449,961.59	$2.047
Haulage to mill	10,360.75	.047
Haulage drift amortization	9,469.10	.043
Milling	121,224.56	.552
TOTAL MINING AND MILLING	591,016.00	2.689
Credits, Rents, Store Profits, etc.	35,861.28	.163
Net OPERATING COST	$555,154.72	$2.526
Eastern expense	7,409.88	.034
TOTAL (before depreciation)	$562,564.60	$2.560
Depreciation	42,533.53	.193
Total	$605,098.13	$2.753

CHRISTMAS MINE

Estimated Present Cost of Producing Copper
Based on Actual Costs for Last Year of Operation.

	Per dry ton	With 3.18% Ore Per lb. copper	With 2.02% Ore Per lb. copper
Ore extraction	$1.597	2.889¢	5.126¢
Development	.196	.354	.628
Pumping	.011	.019	.035
Assaying	.029	.052	.093
Aerial tramway	.033	.059	.105
Mine office	.044	.079	.141
General	.137	.248	.438
TOTAL MINING	$2.047	3.701¢	6.566¢
Haulage to mill	.047	.085	.151
Haulage drift amortization	.043	.078	.138
Milling	.552	.998	1.771
TOTAL MINING AND MILLING	$2.689	4.862¢	8.626¢
Credits, Rents, Store Profits, etc.	.163	.294	.522
	$2.526	4.568¢	8.104¢
Less adjustment of wages to 35¢ and 40¢ base rates for labor	.131	.237	.420
TOTAL	$2.395	4.331¢	7.684¢
Eastern expense	.034	.061	.109
	$2.429	4.392¢	7.793¢
Freight to smelter	.141	.255	.400
Smelting	.138	.250	.493
Freight East, refining & selling	1.382	2.500	2.500
TOTAL	$4.090	7.396¢	11.186¢
Less credit for gold and silver	.429	.776	.776
TOTAL (before depreciation)	$3.661	6.620¢	10.410¢
Depreciation	.193	.349	.620
TOTAL	$3.854	6.969¢	11.030¢

STATE OF ARIZONA
DEPARTMENT OF MINERAL RESOURCES
MINERAL BUILDING, FAIRGROUNDS
PHOENIX 7, ARIZONA

July 8, 1963

Mr. George Pittman, Publications Editor
Kennecott Copper Corporation
Ray Mines Division
Hayden, Arizona

COPY

Dear Mr. Pittman:

I am junior to the deceased Frank Knight who was president of Mineral Products Co. when in 1925 it acquired a controlling interest in the Christmas prop[erty]. He was not, however, the founder of the community of Christmas as mentioned in your letter of June 28th.

You probably have U. S. Geological Survey Bulletins Nos. 771 and 1027-H which cover history to 1947. If not, we can photocopy the pages for you.

I can't tell you when the community of Christmas was founded. It probably was a mining camp about 1882 when Dr. James Douglas acquired the original Tweed claims, sat up two small water-jacketed furnaces and smelted some oxidized ore.

Probably very few lived there from 1884 to 1902 when the area was restored from San Carlos Indian Reservation to public domain and to mining. The Christmas post office was established June 17, 1905 and went out on March 30, 1933.

Mr. Harry Hamilton, former vice-president of New York Trust Company, took a sampling job at Christmas in 1906-7 after leaving school. He told me that there were about 1,000 working there, including those working on the railroad grading.

Disappointment Valley, or Creek, is the lower end of Dripping Springs wash and antedates the latter name, according to Barnes' Arizona Place Names, which says Bourke called it so as early as 1873.

I can't tell you who was with Mr. Jameson on the deer hunt, but it probably was an Asarco man. S. H. Sherman was superintendent at the time. Julius Kürttschnitt, director Mount Isa Mines, Ltd., P. O. Box 1433 T G P O Brisbane, Queens, Australia was in charge in this region and might remember the story. I don't know where Mr. Sherman is, if living.

There have been articles on Christmas and my brother Sam may have one or more. A copy of this is going to him and I'm sure he will be glad to help if he can. He was at Christmas longer than I. One article appeared in the Arizona Republic issue of December 24, 1930. Another was in the Arizona Daily Star of December 23, 1962, and Bert Fireman had a story about an old trunk in the Gazette of March 19, 1958.

Mrs Cooley, State Librarian is a reference familiar to you and her files have information on Christmas.

Yours very truly,

FRANK P. KNIGHT,
Director.

FKip

cc: Sam Knight
4337 East 5th Street
Tucson

CHRISTMAS COPPER CORPORATION

CHRISTMAS, VIA WINKELMAN
ARIZONA

November 21, 1946

Premium Metals file

Mr. Chas. H. Dunning, Director,
Department of Mineral Resources,
304 Home Builders Bldg.,
Phoenix, Arizona.

Dear Sir:

Herewith is the information requested in your letter of November 7th.

We will be glad to cooperate further in connection with your proposed efforts to have metal premiums continued.

Yours very truly,

Christmas Copper Corporation

Frank P. Knight Jr.

Vice President

FPKJr-HB

NAME OF COMPANY Christmas Copper Corporation, Owner
Sam Knight Mining Lease, Inc., Lessee

NAME OF MINE Christmas

(1) Production - January 1st to June 30, 1946, inclusive.

Producers shipping ore direct to smelters or to custom mills use Column No. 1; producers operating their own mill use Column No. 2.

COLUMN NO. 1				COLUMN NO. 2				
	Tons	% Cu	% Pb	% Zn		Tons	% Cu	% Pb	% Zn
Crude Ore	9717	1.92	-0-	-0-	Copper Conc.	-0-			
					Lead Conc.	-0-			
					Zinc Conc.	-0-			

(2) Average Price Received for Metals in Above Production

This to be the total of the ceiling price plus premiums.

Copper 26,775 ¢/lb. Conn. Valley as base

(3) What do you estimate your production would have been, January 1st to June 30, 1946, if the metal price had been:

Cu 14 3/8¢/lb. Conn. Valley; Lead 8.25¢/lb. N.Y.; Zinc 8.25¢/lb East St. Louis (with no premiums)

COLUMN NO. 1			COLUMN NO. 2		
Crude Ore	None	Tons	Copper Conc.	None	Tons

(4) What do you estimate your production would have been, January 1st to June 30, 1946, if the metal prices had been:

Cu 16¢/lb. Conn. Valley; Lead 11¢/lb. N.Y.; Zinc 9.50¢/lb. East St. Louis (with no premiums)

COLUMN NO. 1			COLUMN NO. 2		
Crude Ore	None	Tons	Copper Conc.	None	Tons
			Lead Conc.	"	Tons
			Zinc. Conc.	"	Tons

(5) If a metal Conservation Price Plan, similar to the present Premium Price Plan, were made permanant for at least five years,

(a) What would your yearly production or ore or concentrates be:
Average of over 50,000 tons of ore

(b) Would such a plan cause you to expand your exploration-development program? If so, how much?
Yes. At least triple it.

(c) What effect would such a plan have in increasing your ore reserves?
Should substantially increase them.

(5) (d) In view of low tariffs, how would such a plan promote a healthy mining industry?

This country needs new ore bodies of copper, lead and zinc. Their discovery can only result from expenditure of large amounts of time and money. On the premise that where there's smoke there's fire, small mines, and larger mines that are marginal or even sub-marginal, are the best prospects. Large mines develop from small mines.

During the period from 1942 to date, metal premiums have allowed mines to be reopened, but, because of manpower shortage and inefficiency, most mines have been unable to maintain adequate development and exploration work. It is just that premiums be continued to repair the deficiency.

But perhaps the principal reason for continuation of premiums is to prevent wide-spread shut-down of mines that cannot operate under present inflated costs without premiums. Cessation of premiums in 1946 resulted in widespread shut-downs, although mostly on a stand-by basis because premium restoration was anticipated.

The cost of reopening a mine that has shut down is very high, and in many cases prohibitive. The loss to the country's ore reserves if premiums are not continued through a readjustment period, and beyond if necessary, will be great.

Furthermore, many mines now are looking ahead only to June, 1947. If there were assurance of premiums for another five years, there would be incentive to plan for development, exploration and expansion. Known ore bodies which require say a year's development work including perhaps shaft sinking, might be opened up with some assurance of a profitable period to warrant the capital outlay. In some cases,

such new ore would carry more metal than expected and insure future operation without premiums.

The Christmas Mine has produced 1,325,000 tons of ore containing 63,335,000 pounds of copper. Several million more tons of ore of better grade are estimated by reliable engineers to be geologically probable. The owner believes that unless new capital becomes interested in the mine, it will shut down if premiums are discontinued in 1947. The shut-down would involve flooding of important workings and the probable end of a mine that potentially is an important asset. Continuance of premiums for another five years would offer excellent opportunity to put the mine on its feet as a continuing asset rather than a probable dead loss. It is altogether likely that many other mines have a similar picture.

Huge sums of money will be required to find and develop metal reserves for the start of the coming century. It is doubtful that private capital will make the venture before dangerous scarcity forces metal prices to soar. Should the government be forced to step in before such scarcity, it would find that loss of present developing mines through early premium stoppage would be far more costly than to keep them developing by continuance of premiums.

Premiums should be continued as needed as long as a property is developing and worthy.

OFFICE OF WAR MOBILIZATION AND RECONVERSION

Washington, D. C.

April 8,1947

Mr. Frank P. Knight, Jr., President
Sam Knight Mining Lease, Inc.
Christmas, Arizona

Dear Mr. Knight:

Re: Christmas Mine (Exploration)

Your application for an Exploration Premium, dated February 22, 1947 has been reviewed and the following premium has been assigned:

	Zinc	Lead	Copper
Effective October 1, 1946 to not later than June 30, 1947 Total Premium not to exceed $34,327	---	---	4.8¢

Recommended Exploration Project

Amortization of equipment March 1 to December 31, 1947	$ 1,170
Dewatering and repairing shaft, estimated	6,237
Sinking shaft 20 feet, estimated	2,500
Cutting shaft station, estimated	7,000
Drifting and crosscutting, 670 feet, estimated	17,420
Total Recommended Premium	$34,327

The raise, estimated cost $6,975, was denied as it cannot be classified as exploration work.

You will please note that your present limited exploration premium of 1¢ per pound copper is cancelled April 1, 1947. Please return the original assignment sheet to this office.

Please submit monthly reports containing the information as detailed under "E", page 4 , of your application. Label these reports "Exploration" and your usual operating reports "Mine".

Very truly yours,

C.O.Mittendorf, Director
Office of Premium Price Plan for Copper, Lead & Zinc
Room 2204, "Tempo K"

WAR MINERALS REPORT*

Report of the Bureau of Mines to Secretary of Interior, Harold I. Ickes

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Christmas Mine
Project 1419
Gila County, Arizona

- Copper -

Summary

The Christmas Mine consists of 35 patended and 40 unpatented mining claims located in the Banner Mining District in the Southeast Corner of Gila County, Arizona.

The Mine is ideally situated as regards transportation and accessibility. An 11 mile spur of the Southern Pacific Railroad connects the property with the Hayden Smelter, a unit of the American Smelting and Refining Company. The property is on the Globe-Winkelman highway about 10 miles from Winkelman and about 40 miles from Globe.

The Christmas Mine was discovered about 1880 but because it was on the San Carlos Indian Reservation, little was done until the reservation boundaries were shifted in 1902 to exclude this mineral area. From 1905 to January 1, 1944, the mine produced 1,268,913 tons of ore yielding 50,752,114 pounds of copper. The present operation is under the supervision of Mr. Sam Knight, lessee. From 1940 to

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* The War Minerals Reports of the Bureau of Mines are issued by the United States Department of the Interior to give official expression to the conclusions reached on various investigations relating to domestic minerals. These reports are based upon the field work of the Bureau of Mines and upon data made available to the Department from other sources. The primary purpose of this report is to provide essential information to the war agencies of the United States Government and to assist owners and operators of mining properties in the production of minerals vital to the prosecution of the war.

February 1, 1943, Knight shipped from 3,000 to 3,500 tons of ore per month to the Hayden Smelter for basic flux. Since February 1943 production has decreased to 1,558 tons in December 1943. However, upon completion of the present program to develop ore indicated by Bureau of Mines drilling, production should return to it's normal level.

The ore bodies are of pyrometasomatic origin, partially replacing favorable limestone beds adjacent to a dioritic intrusive. The ore is localized near the contact in heavy garnetized areas. The chief ore materials are the copper sulfides, chalcopyrite and bornite with varying amounts of chalcocite, native copper, chrysocolla, and cuprite. The gangue is heavily garnetized limestone with some pyrite.

Diamond drill prospecting of previously unexplored areas in the mine was undertaken by the Bureau of Mines in 1942. Drilling was started on September 12, 1942 and completed on January 18, 1944. During this time, 32 holes aggregating 5,946 feet were drilled. Results of this work indicate a reserve of 97,200 tons of 2.30 percent copper. Allowing 10 percent lost for ore left as pillars this reserve is reduced to 87,500 tons of recoverable ore. The tonnage indicated has been divided into two classes, namely reserves below the 770 level, termed inaccessible which cannot be developed except by a major program not contemplated at present, and reserves above the 770 level, termed accessible. The accessible tonnage added by Bureau of Mines drilling is 64,100 tons of 2.2 percent copper and the inaccessible tonnage is 23,400 tons of 2.6 percent copper. The total accessible ore for the mine or that tonnage in development areas now being mined, together with that indicated by Bureau drilling, is

74,100 tons of 2.2 percent copper. The total inaccessible ore which includes ore indicated by Bureau drilling and by previous drilling by the Harvey Mudd interests, is 57,900 tons of 2.5 percent copper. The overall total mine reserves are estimated at 132,000 tons of 2.3 percent copper. These figures are based on a cut-off grade of 1½% copper.

There are several principal levels in the mine which are serviced through No. 3 shaft, 908 feet deep. Room-and-pillar stoping is the accepted method of mining the deposit, although square-setting shrinking, and horizonal cut-and-fill have been experimented with. The room and pillar method is well adapted to the attitude of the beds which dip 10° to the southeast. Where the mine has been drained before stoping was started, the ground stands well with little timbering, but on the lower levels, where drainage is not complete, the ground is heavy and requires close timbering and maintenance.

The mine equipment is being modernized by the lessee who is replacing wheelbarrow transportation of the ore in the stopes by "slushers." A mine car loader recently purchased has replaced hand mucking in the development headings.

Other equipment on the property consists of a 500 flotation unit which was in use from 1929 to 1931, compressors and drills, machine shop, blacksmith shop, warehouse, filter plant, and framing shed.

Power is drawn from the Coolidge Dam power line which crosses the property in the vicinty of No. 3 shaft.

Enough ore has been indicated by Bureau drilling to insure normal production for a minimum of 2 years. It is probable that when the drilled areas above the 770 level are fully developed they will yield sufficient tonnage to maintain production for a considerably longer period.

Should a major development program be undertaken to open the 900 and 1,000 foot levels, the life of the mine would be materially increased and the grade of the ore raised. The present method of mining would be unsuited for the levels below the 770 level unless the area was throughly drained and the ground given a chance to "set". One of the varied mining methods employing fill would probably be found suitable.

The depth of the deposit has not been determined but it is believed that development at depth may disclose reserves equal to or in excess of the total production of the mine to date.

INTRODUCTION

An Engineer of the Bureau of Mines[1] visited the Christmas property from May 29th. through June 2nd., 1942, investigating the feasibility of diamond drilling the ore deposit for the purpose of increasing ore reserves. In his report, he recommended the drilling of six holes, aggregating 1,165 feet, from the 770, or bottom level of the Christmas Mine.

Invitations for bids for a minimun of 2,000 feet of drilling were sent out on August 3, 1942. Bids were opened on August 17, 1942 and the contract awarded to the Southwestern Drilling and Development Company. The Contractor arrived on the property on September 10, 1942 and drilling was started on September 12 at noon. From September 12, 1942 to May 21, 1943 the Southwestern completed 13 holes totaling 2,241 feet. On June 1, 1943 a contract was let to the Sullivan Machinery Company for an additional minimum 1,000 feet of drilling. From June 17, 1943 to January 18, 1944, Sullivan completed 19 holes totaling 3,705 feet.

Location and Accessibility

The mine is located in the southwestern corner of Gila County

[1] Fisher, O.M., mining engineer

(fig.1) 10 miles north of Winkelman, Arizona, on the Globe-Winkelman highway, a well maintained gravel road. It is in the Banner Mining District which covers the Dripping Springs Range.

The property is ideally situated as regards transportation and accessibility. An 11 mile spur of the Southern Pacific Railroad connects the property with the Hayden Smelter, a unit of the American Smelting & Refining Company. Supplies are obtained either from Globe or Winkelman by truck.

The collar elevation of No. 3 shaft, the main operating shaft, is 3,082.77-[2] feet. The camp proper is about 400 feet lower while the elevation of the railroad spur, power house, and abandoned filter plant is 2,050, about 20 feet above the adjacent Gila River.

Climate and Vegetation

The Climate of this locality is mild in the winter, although snowfall is not uncommon, with considerable rain during the months of January and February. The Summers are extremely hot and dry. The vegetation is typical of the hills of southern Arizona, consisting mainly of cholla, saguaro, yucca, mesquite, and catclaw with some palo verde. Scattered cottonwood is found along the Gila River. There is no timber suitable for mine or building purposes.

PROPERTY OWNERSHIP AND DESCRIPTION

The property is owned by Christmas Copper Corporation, Frank P. Knight, President; Roland Knight, Treasurer; Frank P. Knight, Jr., General Manager and Vice-President, with main offices located at Beverly Farms, Mass. The mine is being operated under lease by Sam Knight, also of Beverly Farms, Mass. The property, consisting of 35 patented and about 40 unpatented claims (fig.2), has tax and other liens against it.

[2] Elevations used herein are mine elevations and are 40.73 feet higher than U.S.G.S. elevations.

Power, formerly generated at the property by a company-owned 1400-kw. Diesel-electric installation, recently purchased by the Indian Service, Department of the Interior, is now drawn from the Coolidge Dam power line which crosses the property in the vicinity of No. 3 shaft. Water for domestic and general camp use is obtained from the mine. While the mill was in operation, the necessary water was pumped from the Gila River, 1 mile east.

Surface buildings and equipment on the property consist of a 100 ton filter plant, a 500-ton flotation mill, one wooden and one steel headframe with complete hoisting equipment for both, a timber framing shed, blacksmith shop, warehouse, assay office, machine shop, store, general office, engineering office, school, bunkhouses, and private dwellings. Most of the fram and abode buildings are in poor condition.

HISTORY AND PRODUCTION

The mine was first located by Dennis O'Brien and William Tweed about 1880. They sold or aptioned the property to the Phelps Dodge Company and Dr. James Douglas erected two small smelting furnaces. In 1884, the company was forced to suspend operations becaus e the area was inside the San Carlos Indian Reservation. On December 22, 1902, the Reservation boundaries were shifted to exclude the mining property, and on Christmas eve, G. B. Chittenden located a group of claims to cover the deposit and named the property the Christmas Mine.

The Saddle Mountain Mining Company was formed to hold and operate the property, and a smelter was erected; 113,322 tons of ore was mined prior to 1907 when the company failed.

In 1909, the Gila Copper Sulphide Company was formed to operate the property, which they did without production until about 1914. At about that time they borrowed money from the American Smelting & Refining

Company and entered an agreement whereby the latter were to smelt the ore for 10 years, but as a condition of the loan, were to manage the property until the sum borrowed was repaid. Shipments began in February 1916, and the loan was paid in November, 1916. Thereafter, until January 1919, the Smelting company continued Management on the fee basis. The company continued to operate until the depression of 1921.

Between 1921 and 1926, the bondholders instituted foreclosure proceedings because of defaulted bonds and a new corporation known as the Christmas Copper Company was formed. Operations were resumed in 1926 and continued until 1932. During this period a 500-ton capacity mill was built. In 1935-36, the company was reorganized as the Christmas Copper Corporation under article 77B of the Bankruptcy Act and the mine was reopened but was forced to shut down again in March, 1938 because of the low price of copper.

In 1939, with the advent of a better price and a favorable smelting contract, operations were resumed by leasing and in 1942, 2,500 to 3,500 tons of ore were being shipped to the Hayden Smelter each month.

The Christmas Mine produced 1,268,913 tons of ore from 1882 to 1943, (see Appendix 3), from which 50,752,114 pounds of copper was recovered by smelting. In the past, the bulk of the production came from stopes on and above the 400 level. Because of depletion of ore reserves, very little work is being done at present above this level, the main development effort being directed to the lower levels. Project drilling from the 800 level has increased the production life of the upper levels and probably will furnish sufficient ore to maintain the present production rate until the reserves being developed below the 400 can be brought into production. Until such time until the mine is deepened, only that country between the 635 and 400 levels can be depended upon for any appreciable output. Because additional handling will be required to deliver ore mined below the 400 to the ore bins

and because the bulk of future production will come from this area, some increase in the cost of mining can be expected. During 1943, production has declined from 3,073 tons in January to 1,558 tons in December. However, upon completion of the present development program opening reserves indicated by Bureau drilling, normal output of 3,000 to 3,500 tons per month should again be possible.

Disposition of Mined Ore

The Christmas ore is purchased by the Hayden Smelter as a basic flux. The composition of the ore varies considerably in different parts of the mine, but the average analysis will closely approach the following:

Silica	32 percent
Lime	30 do.
Alumina	2 do.
Silver	.23 do.
Sulfur	3 do.
Gold	.003 oz.
Iron	11 do.
Copper	2.20 Percent

The smelter deducts 8 pounds of copper per dry ton of ore and pays for the remainder at 11.775 cents per pound, the present quotation for electrolytic cathodes. Lime is paid for at the rate of 10 cents per unit over 15 percent, limited to treatment charge or $1.50 per ton, whichever is less. Base treatment charge is $1.38 per dry ton plus 15 cents per dry ton for each 1 cent increase in the quotation for cathodes above 11.775 cents per pound, up to a maximum base charge of $2.00 per ton. The base charge is also subject to adjustment to compensate for changes in the wage scale at the smelter.

The lessee is receiving a premium of 15 cents per pound of copper from the Metals Reserve Company, based upon 97 percent of the copper assay, smelter's figures accepted.

Appendix 2 is a recapitulation of smelter returns during 1943.

GEOLOGY

General

The Christmas copper deposit is a typical contact metamorphic deposit being a replacement of favorable limestone beds adjacent to a dioritic intrusive. The generally accepted theory covering the ore genesis is that the diorite was intruded into the limestone in the form of a plug with attending diorite sills and dikes. The intrusion was accompanied by garnetization of favorable limestone beds near the contact. This was followed by the mineralizing phase with the copper-bearing solutions permeating the garnetized, favorable limestones and depositing copper sulfides.[3]

The deposit as defined by mine workings appears in the shape of a semioval with the open side to the north east and the enclosure assumed to be diorite (figs. 3 &4). The eastern limit of the deposit is the Christmas fault which has a general strike of .35°- 40°W. and a dip of 70°-80°NE. To the southwest the diorite fades out in a series of thinning dikes or fingers.

The ore occurs in the upper part of a series of Paleozoic sediments which are overlain by a thick andesitic flow.[4] The sediments dip 10° to the southeast and outcrop prominently around the deposit. The center of the area is covered with a mantle of alluvium and there are few outcrops.

The Diorite

The instrusive is a quartz-biotite-diorite of two ages, an early fine and a late coarse-grained phase. Some biotite-hornblende-diorite has also been noted. In general the sills are fine-grained and are difficult to distinguish from the metamorphosed shales. Solution

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[3] Abstract from report by Harrison A. Schmitt.

[4] Federal Geological Survey preliminary report.

or reaction with the shales is common, while evidence of digestion of the limestone is rare.

The diorite dike or finger formations are best shown by the mine development on the west end of the deposit (figs. 3,4, & 28). The Christmas fault to the northeast delimits both the diorite and the sediments.

Locally the contacts between the diorite and the sediments are very irregular and are characterized by a magnetite-pyrite zone varying in thickness from 6 inches to 5 feet. Gouge is also noted at the contact.

The copper contact of the diorite runs from 0.07 to 0.75 percent, the average being about 0.40 percent. The assays of the samples from No. 2 hole (fig. 9 and appendix 1) are fairly representative of the copper content in the diorite near its contact with the limestones.

The diorite, as exposed in stopes and drifts, is fractured and blocky. When exposed to the air it disintegrates rapidly and requires timbering in most cases. Where sloughing of the diorite has arched narrow drifts, no timbering is required. However the walls and backs of such openings are danger spots and require constant attention. With few exceptions the ground is heavy in fault zones and requires timbering.

The Sediments

The sediments are composed of alternating limestones and shales with the former predominating. Most of the ore so far mined has come from 14 definable limestone beds. Beds not included in this correlation have been mined on the 635 and 770 levels.

Las Novias series is the thickest and apparently the most favorable for ore deposition. This series has contributed the largest part of the accessible ore shown by Bureau drilling. Las Novias has produced more and better grade ore than any of the other beds in the section. In some areas this bed has been mined for its thickness of

60 feet, but generally ore bodies within the series are separated by relatively barren strata of shale or shaly limestone.

The following is a tabulated section through the above mentioned 14 bed s taken from the correlation chart by the Federal Geological Survey:

32 feet of sediments
240 Beds
7 feet of sediments
0X-15U Beds feet thick
10 feet of sediments
0X-15 Beds.....10 feet thick
13 feet of sediments
0X-14 Beds..... 9 feet thick
5 feet of sediments
J Beds.....40 feet thick
15 feet of sediments
50 Beds.....20 feet thick
15 feet of sediments
85 Beds.....10 feet thick
20 feet of sediments
Johnny Bed..... 7 feet thick
47 feet of sediments
205 Bed.....9 feet thick
6 feet of sediments
220 Bed.....16 feet thick
9 feet of sediments
235 Bed..... 7 feet thick
8 feet of sediments
250 Bed.....12 feet thick
5 feet of sediments
Las Novias.....60 feet thick

The limestone and shale backs in the stopes and drifts stand well in a drained areas. However, in the old workings and especially in those showing heavy shear, the backs tend to peel off on bedding planes. This is apparently the result of exposure and not due to pressure of overlying strata. The backs of newly developed stopes in drained areas remain in good condition for a longer time than required to complete the stope. In areas newly opened and not drained the ground sloughs soon after it is opened. In these areas a change in the stoping method would be required.

Ore Occurrance

The ore deposits are of metasomatic origin, replacing favor-

able limestone beds near the limestone-diorite contact. Mineralization extends from 50 to 200 feet outward from the diorite into the limestone. In the narrow zone along the contact the chief minerals are magnetite and pyrite. Beyond this, to the limits of mineralization, the limestone as garnetized and cantains varying amounts of copper minerals. The mineralization grades outward into marble or unaltered limestone.

The principal ore mineral is chalcopyrite, but some bornite, chalcocite, and in lesser amounts, oxidized copper minerals, usually are present. Near the surface and at various places along the south contact considerable oxidation has taken place. The gangue is chiefly garnet, quartz, and unreplaced limestones.

Factors controlling localization of the ore can be summed up as follows: (1) The location of the diorite; (2) the existence of favorable limestone beds; (3) garnetization of these beds; (4) the facturing of the favorable, garnetized beds allowing the permeation of ore bearing solutions with subsequent deposition of the copper minerals.[4]

In some instances the mineralization of ore grade starts at the contact but generally occurs from 10 to 25 feet from the diorite and extends from 75 to 100 feet outward into the linestones. The outline of the area mineralized by the copper-bearing solutions depends upon the extent of the garnetization and the shearing. The stope boundaries do not conform with the above but are governed by grade of ore. In the narrow beds the stope height is uniform, limited by the overlying and underlying shale beds. In the thick beds, such as the J bed and the Las Novias series, the stope height is irregular with much thickening and thinning.

EXPLORATION

Prior Diamond Drilling

In 1916, the American Smelting and Refining Company drilled 7 holes totalling 2,337 feet. Three holes were drilled from the stopes on the north side of the 300 level. Ore beds shown by these holes were later developed and mined. One hole was drilled from the 400 level and bottomed on the 770 level, above Federal Bureau of Mines hole 3. The last 33 feet assayed 1.88 percent copper which was the highest in the hole. Three holes were drilled from the surface, one of which showed 15 feet of 2.00 percent copper. All holes were vertical.

During 1930, the Christmas Copper Corporation drilled four holes aggregating approximately 2,000 feet. This drilling was confined to the country below the 770 level, most of it in the vicinity of No. 3 shaft, with the exception of one hole which was drilled from the surface near No. 4 shaft. Most of the records of this drilling have either been lost or were destroyed at the time the engineering office burned. However, from data available it appears that the results of this drilling were not encouraging.

In 1941 the Harvey Mudd interests drilled 11 holes totalling 3,109 feet. This drilling was confined to the country below the 770 level. 773 drift was also sampled and, in the vicinity of what is now 773 stope, assayed 3.5 percent copper.

Work by the Bureau of Mines

Southwestern Drilling and Development Company, under contract to the Federal Bureau of Mines, drilled 13 holes aggregating 2,241 feet. The contractor arrived on the property on September 10, 1942. Active drilling began at noon on September 12, 1942. Upon completion of diamond drill hole 12 on May 21, 1943, this contract was terminated. On June 1, 1943, a new contract was entered into with the Sullivan Machinery Company

for an additional minimum 1,000 feet of drilling. From June 17, 1943 to January 18, 1944, 19 holes totaling 3,705 feet were completed under this contract. The total drilled by the two contractors for the Bureau of Mines was 5,946 feet.

A preliminary investigation of the Christmas Mine was made by O. N. Bishop from May 29 to June 2, 1942. As a result of his field work, Bishop recommended six holes, aggregating 1,185 feet to be drilled from the 770 level. This proposal was carried out with the exception of hole 4, which was not drilled, and with the addition of diamond drill hole 7 which was drilled to supplement the information obtained in hole 3. When it became apparent that ore below the 770 level would not be mined at this time because of the extensive and costly development required, it was decided to move to the upper levels, in an attempt to locate ore reserves that would be more readily accessible.

In the following description of the drill holes, the term ore is applied to those mineralized zones assaying more than 1.50 percent copper. All zones suspected of carrying more than 0.50 percent copper were assayed (see Appendix 1). A summary of ore reserves will be found under the heading, "Ore Reserves."

Hole 1 (fig.8) was drilled upward at an angle of 10° from the west end of 809 drift. The bearing of this hole is N. 30° W., depth 173 feet. Because of the intense shear through adjoining drifts and stopes, it was thought that ore might be found on to the northeast beyond the diorite finger that cut off the ore in the adjacent stope. No mineralization of any consequence was encountered in the hole and no samples were sent in for assaying.

Hole 2 (fig.9) was drilled horizontally from 773 drift, 770 level. The bearing of this hole is S. 16° W., depth 195 feet. The existence of a bay between two diorite fingers enclosing sedimentary

rocks and extending westward was indicated by exposures in 809 drift. Hole 2 was drilled to prospect the supposed bay.. It was found that the bay was small and the enclosed sediments contained little copper. These results discouraged additional drilling in this area.

Hole 3 (fig. 10), bearing N. 49°E., dip-55°, depth 146.5 feet; the workings to the north of 809 drift are inaccessible. However, the mine maps indicate the existence of a definite bay between diorite fingers. The heavily mineralized 773 bed dips toward this bay and under 809 drift. Ore intersections were encountered between 11 and 36 feet and between 56 and 120 feet. Inasmuch as the trend of the enclosing diorite was fairly well known in the immediate area and because the mineralization, as shown by drilling, extended to the diorite contact, ore blocks were assumed as being 80 feet along and extending 60 feet away from the diorite contact. This hole indicates 21,800 tons of 2.73 percent copper.

Hole 5 (fig.11), located at the northern extent of 817 drift, 770 level, bearing N. 50°E., dip-10°, depth 268 feet, was intended to explore the area between the diorite finger to the south and the one to the north. This area of sediments as shown by workings on the 200, 300, and 400 levels, is quite extensive and has been one of the most productive areas on the upper levels. No mineralization of any consequence was found in hole 5. The width of the sediments was shown to be about 255 feet at this level. Diorite was encountered between 115 feet and 136 feet, Magnetite and pyrite were found in most of the core, indicating close proximity to a diorite contact. The presence of the contact minerals and the diorite seem to bear out the assumption that the drilling was skimming the diorite forming the east boundary of the bay.

Holes 6 and 6A (fig.11): Hole 6A, bearing N. 50°E., dip-75°,

depth 147.5 feet, was drilled from the same setup as hole 5, but below the 770 level. This drilling was intended to prospect the same bay explored by hole 5. Ore was intersected from 7.6 feet to 28 feet, indicating 1,400 tons of 3.61 percent copper. At 42 feet, drilling passed into contact structure with mineralization of magnetite and pyrite. The hole bottomed in diorite which was assumed to be the bottom or eastern boundary of the bay area. It is possible that greater ore thickness or additional ore zones might have been found, had the hole been pointed more to the northwest, which is the general dip of the eastern boundary of the bay. Hole 6 was drilled from the same location as hole 6A, but was lost at a depth of 75 feet because of badly broken and caving ground.(Note: From 137 to 146 feet sludges averaged 2.28 percent copper.)

Hole 7 (fig. 10), bearing N. 70°E., dip-63°, depth 146 feet, was drilled to obtain information to supplement that obtained in hole 3 concerning the mineralization of the bay area. Three ore zones were cut - one from 17 to 22 feet, one from 67 to 72 feet, and one from 82 to 87 feet. This hole added 2,800 tons of 1.98 percent copper to the indicated ore reserves. This was the last hole drilled from the 770 level.

Hole 8 (fig. 12), located in 328 drift, 300 level, bearing N. 15°E., dip-70°, depth 288 feet, was intended to prospect Las Novias bed below the 300 level. Drilling apparently followed the contact zone as evidenced by the character of the core. Some native copper and chalcopyrite were found but never in sufficient quantities to make ore.

Hole 9 (fig. 12), drilled from the same location as hole 8, bearing N. 15°E., dip-80°, depth 243 feet, also failed to find ore and showed only occasional mineralization in the form of native copper and chalcopyrite. It was definitely proved by this drilling that the Las Novias series in this immediate area was marbleized and, therefore,

unfavorable for ore.

The subsequent drilling (holes 10, 11, 12, 13A, 13B, 13C, and 14) from the 400 level was undertaken for the following reasons: The 400 and 500 level stopes along the south diorite contact were in the 50, 85, and Johnny beds. The 205, 220, 235, 250, and Las Novias beds, from which much of the ore mined along the north contact was derived, were virtually unprospected in this area. The general dip of these beds is to the northeast, steepening toward the east of the section. 508 stope on the 500 level was thought to be in the top of the Las Novias series which would place the four overlying beds above the 500 level. This stope is located on the west of the section under consideration. On the east of this section all but the 205 bed are below the 500 level and above the 635 level. Because of lack of development on the 635 level, the east drift having been extended only 130 feet from No. 3 shaft, the area east of the 6600 coordinate was unprospected. The shear structure as shown in 530A and 512A stopes is strong and because of the intensity of the shearing it was thought probable that the same favorable conditions for mineralization would extend to depth. The 500 level for the most part is inaccessible. That part which is accessible would require considerable expenditure and time to repair. It was, therefore, decided to drill all holes from the 400 level. The general trend of the diorite contact and the shear zones were known from exposures on the 400 level. A study of stope boundaries led to the conclusion that the most favorable point to intersect supposed ore zones was about 50 feet from the diorite intrusive. The average width of the stopes in this section was found to be about 50 feet.

Hole 10 (fig. 13) was drilled from 530A stope, 400 level, bearing N. 35°E., dip-67°, depth 201 feet. The ground penetrated by

This hole was badly Broken, resulting in poor core and sludge recovery. Of ten samples assayed only one contained more than 1 percent copper (1,23 percent).

Holes 11 and 12 (fig. 14) were drilled from 530A stope. Hole 11 was intended to verify the location of the diorite intrusive and checked the projection within 5 feet. Hole 12, bearing N. 16°E., dip-75°, depth 207 feet, was then drilled to roughly parallel the contact about 50 feet from the diorite. Of 23 samples assayed, only 8 were above 1 percent, the highest being 1.43 percent. Although neither hole was considered to have shown ore, further exploration of this mineralized area is believed warranted.

Holes 13A, 13B, and 13C (figs. 15, 16, 17, 18, 19) were drilled from 416 drift. Hole 13A, bearing N. 15°E., dip-50°, depth 232 feet, was a contact hole needed to verify the location of the diorite. Ore was encountered from 31 to 43 feet and from 192 to 200 feet, indicating 1,500 tons of 2.16 percent copper. Utilizing the information obtained from Hole 13A, 13B was drilled with a bearing of N. 15°E., a dip of -73° and bottomed at 354 feet. Ore zones were found from 166 to 190 feet, 200 to 205, and 212 to 217 feet. The hole indicated 11,000 tons of 2.03 percent copper. Hole 13C, bearing N.67°E., dip -53°, depth 392 feet, was intended to prospect the eastward extension of the ore zones shown in the two previous holes. Ore was encountered from 227 to 232 feet, 237 to 252 feet, 255 to 272 feet, and 311 to 326.5 feet, indicating 17,300 tons of 2.08 percent copper.

Hole 14 (figs. 15, 16, 18), bearing N. 30°E., dip-73°, depth 303 feet, was drilled from the eastern end of 530A stope and roughly half way between the barren hole 10 and the No. 13 hole. Ore was encountered from 80 to 85 feet, 105 to 110 feet, 127 to 131 feet, 139 to 164 feet, 167 to 172 feet, 177 to 182 feet, and 192 to 202 feet,

indicating 19,200 tons of 2.25 percent copper.

The presence and distribution of the ore at the site of 412 stope, some distance south of the main contact zone, has been attributed to the presence of a diorite finger south of the stope, thought to be a part of the same finger lying to the west. The immediate mine workings show strong shear with a northeast trend. 412 stope is located in the Johnny bed, opening the possibility of ore existing below the stope in the 205, 235, 220, 250, and Las Novias beds. Holes 15A and 15B were drilled to explore this area.

Hole 15A (fig.20) was drilled with a bearing of N. 18°E., dip-43°, depth 235 feet. Ore was found from 181 to 196 feet and from 211 to 216 feet, adding 3,500 tons of 2.30 percent copper to the reserves.

Hole 15B (fig. 20), a vertical hole bottoming at 250 feet, was also drilled from 412 stope and intersected ore from 171 to 207 feet. Six thousand three hundred tons of 2.32 percent copper was indicated by this hole.

As the available ore reserves of the mine were nearing depletion and production was falling off, a "short hole" program was started, designed to locate ore zones in or near active workings which could be opened with a minimum of lost time. The reserves added by this program were expected to be relatively small but sufficient to maintain production until reserves below the 400 level were opened and ready for mining.

Hole 16 (fig. 21), bearing due north, dip plus 30°, depth 213 feet, was drilled from 428 stope. This stope is in the Johnny bed, while the stopes on the 300 level are in the bottom of the J bed with the 80 and 85 beds between the two levels unexplored except at points on or past the limits of probable ore. It was also desirable to test the thickness of the main diorite at this point. Ore was found from

31 to 40 feet and from 48.5 to 56 feet, adding 4,500 tons of 1.93 percent copper to the reserves. Preparations for production from this area was started promptly.

Holes 17A, 17B, and 17C (fig.22), were drilled from 424A stope, 10 feet below the 300 level to prospect the 50, 85, and Johnny beds. The stopes on and immediately below the 300 level at this point are in the bottom of the J bed. Hole 17A, bearing N. 27°W., dip-50°, holed an inaccessible intermediate drift, the location of which had been in doubt, at a depth of 35 feet and was abandoned. Hole 17C, bearing due north, dip-70°, depth 105 feet, was pointed to pass under this intermediate drift. Ore was found from 26 to 46 feet and from 65 to 74 feet, adding 4,500 tons of 2.59 percent copper to the ore reserves. This area is also being opened by the lessee. Hole 17B, bearing S. 75°W., dip-40°, depth 101, was drilled to explore the possible ore beds beneath the 300 level stoping to the west. No ore was found except 4 feet in the bottom of the stope, which was also cut by the other two holes. The unmined 4 feet in the floor of the 424A stope added 200 tons of 2.30 percent copper to the reserves.

Holes 18A, 18B, and 18C (fig. 29) were intended to prospect the area below 458 stope, east of the fault forming the western boundary of the stope. It was known that a filled stope existed below 458 stope but its definite boundaries were not known. Holes 18A and 18B both holed this gobbed stope when an attempt was made to drill through what was thought to be a pillar. Hole 18C was then drilled from 342 drift with a bearing of N. 40°W., dip-66°, depth 121 feet. Ore was encountered from 21 to 39.5 feet and from 50 to 56 feet, indicating 2,800 tons of 2.00 percent copper ore.

The stopes on and above the 200 level extend some distance south of the main area of mineralization which closely follows the main

south contact zone. This suggested that a diorite dike might exist south of the limits of 240 stope, which would explain the presence of mineralization so far from the main diorite contact. If this were so a considerable area below 240 stope could be considered potential ore-bearing ground. to test this possibility, Hole 19 (fig.24) bearing due south, horizontal, depth 196 feet, was drilled from 354 drift. Some mineralization was encountered at the start of the hole but because of its location and spotty character was not considered ore. The hole bottomed well past the limits of the stopes above and failed to show the presence of diorite. It may be that the fault limiting the 240 stope on the west is pre-mineral. Its location and trend are such that it could have been responsible for the mineralization in 240 stope as well as for that in 358 stope. There is no conclusive evidence to determine whether the faulting occurred before or after the period of mineralization.

Hole 20 (fig. 25) bearing S. 35°E., dip plus 75°, depth 100 feet, was drilled from 412 stope to prospect the 80 and 85 beds above the stoped area. No mineralization of any consequence was found.

Hole 21 (fig. 25) bearing N. 80°E., dip plus 67°, depth 94 feet, was drilled from 412 drift to explore the Johnny bed north of the fault that marks the north boundary of 412 stope. Ore was found from 9.5 to 19 feet, adding 400 tons of 2.43 percent copper ore to the reserves. Sometimein the past, a raise had been started at this location but the search for the ore was, apparently, to the west rather than to the east. The lessee repaired 412 drift and is now stoping this ore.

Referring to the 300 level map (fig. 3), a large and heavily stoped embayment north of No. 1 shaft will be noted. This embayment is also shown on the 400 level (fig. 4) and on the 770 level as prospected by hole 5 (figs. 7 and 12). Above the 400 level the embayment was the most productive area in the mine and yielded the best grade of ore.

The country between the 400 and 770 levels was considered a good prospect and was explored by the next three holes.

Hole 22A (fig. 26) was collared in 410 drift with a bearing of N. 30°W., a dip of -57°, and bottomed at 313 feet. The purpose of this hole was to locate the north diorite finger of the embayment in the vicinity of the 635 level. An unexpected thickness of sill diorite was encountered by this drilling, the finger proper being located at a depth of 261 feet. Utilizing this information the strike and dip of hole 22B was determined.

Hole 22B (fig.26) was drilled from the same location as 22A, with a bearing of N. 55°W., and a dip of -60°. This hole was originally intended to bottom at the 770 level. At a depth of 91 feet an open fault was encountered, producing a heavy flow of sericitic sand. After considerable difficulty the hole was advanced to 97 feet. Attempts were made to cement and case the caving hole. With the drill rods 18 feet off the bottom of the hole and the inflow of sand and cave increasing, the hole was abandoned.

Hole 22C (fig. 27) was collared 30 feet to the north of 22A and 22B holes with a bearing of N.65°W., and a dip of -55°. This hole bottomed at 480 feet, at the elevation of the 770 level; 298.5 feet, or 61 percent of the 480 feet of drilling was in dioritic sills. The only noteworthy mineralization found was between 266 and 282 feet (1.91 percent Cu). Because of its location in relation to the enclosed diorite sills and the excessive development necessary to open the probably small block, this ore was not considered economically minable and no estimate of the possible tonnage was made. The results of this drilling discouraged further search for ore reserves in this area. Hole 22 C, completed on January 18, 1944, was the last hole drilled.

General Procedure

The bearings of all holes were set by transit and the dips by Brunton. The mine level surveys have been checked and rechecked by company engineers. The majority of the old survey stations were set in plugs and as there is no ground movement in the Christmas mine, the company's surveys were accepted after a few short check surveys had been made. In setting a drill, care was taken that the original transit set-up and back sight were under stations set in plugs and in good condition.

The original sludge tanks used on Project 1419 were constructed of three 50-gallon oil drums welded together, end to end, after about one-third had been cut away. The ends were left intact and, after welding formed a double baffle. With the open or cut away side turned up, a trough approximately 2 feet wide, 1-1/2 feet deep, and about 9 feet long with three sets of double baffles, was formed. The baffle on the down current side of each set was cut free at the bottom to facilitate cleaning. A 2-inch cleanout plug was welded in the bottom of each section and four 1/2 inch drain plugs were welded down the sides. Two of these tanks were constructed in one day at a cost of about $10. Where working space was unlimited these tanks were very satisfactory. However, where drilling was done from a drift or other close quarters, three or four wash tubs with cut down carbide cans set in them were used. A 1/2 inch nipple and elbow were welded near the top rim of each tub. In use the tubs and cans were arranged in the following manner: The sludge pipe discharged into a can set inside the first and highest tub. The discharge from this tub passed into the next lower can and tub combination, and so on until the water was discharged from the last tub. In the case of the three-tub arrangement, the sludge would pass over six baffles. Good results were obtained with

this set-up although greater care was needed in decanting the tubs than in the draining of the original tanks. Sludges were transferred to the surface in clean, rust-free carbide cans where they were dried by the night hoistman, a Bureau employee.

Core was sent to the surface at the end of each shift in locked core boxes where it was transferred to open core boxes.* At the termination of the project all core which had not been shipped for assaying, was relinquished to the Christmas Copper Corporation.

The specific gravity of the Christmas ore was determined from tests made on 16 representative samples taken from six drill holes and from four mine samples. These tests showed an average specific gravity of 2.66 or 12 cubic feet per ton, which is the figure used in estimating reserves.

In determining the size of the ore blocks, the extent of the stopes above or below the ore zone was considered, as well as evidences of structural features favorable to ore deposition, such as zones of intense shearing. Where exposed in the mine workings, shear zones have been found to persist vertically for considerable distances. The outlines of old stopes present conclusive evidence that some of the ore-bearing beds were more favorable for replacement and ore deposition than others, and the mineralization was more extensive. For example stopes in beds of the Las Novias series are larger than those in the less favorable Johnny bed. All these factors were taken into account in determining the dimensions of the ore blocks assumed to be indicated by drilling.

A tabulation of drilling data and cost for each hole will be found in Appendix 3.

Of the 5,946 feet drilled, 1,588.8 feet was BX with a core recovery of 59 percent; 3,158.1 feet was AX with a core recovery of 56

* All core was kept under lock and stored in an unused room in the abandoned warehouse.

percent,,and 1,199.1 feet was EX with a core recovery of 42 percent. The total core recovery was 3,226.8 feet or 54 percent of the total footage drilled.

Seven holes were reamed for a total footage of 495, or 8 percent of the footage drilled. Eighteen holes were cemented for a total of 1,299 feet or about 22 percent of the footage drilled. Twenty-four holes were cased for a total of 2,406 feet, or about 40 percent of the footage drilled.

Under an operating agreement with Sam Knight, lessee, the Bureau of Mines paid for power consumption over 45,383 kwh. per month, which was the average consumption for the 12 months from September 1941 to August 1942. The power cost was paid at the current rate which varied from.75 cent to 1.0 cent per kwh. One-half of the day hoistman's wages was also paid by the Bureau.

During the greatest part of the project the Bureau crew consisted of a sample foreman, two samplers, and a night hoistman. Whenever considerable rehabilitation work was required to give access to drill sites, miners from the lessee's crew were placed on the Bureau pay roll.

Project Costs

The two drilling contractors were paid in accordance with the following schedule of prices.

	BX per ft.	AX per ft.	EX per ft.	Reaming per ft.	Cementing per ft.	Casing per ft.
Southwestern Drilling and Development Co.	$2.50	$2.20	$2.00	$1.25	$1.25	$0.50
Sullivan Machinery Co.	2.95	2.70	2.45	1.50 1.00	1.50	no

The following is a comparison of the cost of the two contracts:

	Southwestern			Sullivan		
	Feet	Cost	$/ft.	Feet	Cost	$/ft.
BX-size hole	461.8	$1,154.50	$2.50	1,127	$3,324.65	$2.95
AX-size hole	1,343.1	2,954.82	2.20	1,815	4,900.50	2.70
EX-size hole	436.1	871.20	2.00	763	1,869.35	2.45
Total drill	2,241.0	$4,980.52	$2.22	3,705	$10,094.50	$2.72
Reaming AX to BX	54.0	67.50	1.25	352	528.00	$1.50
Reaming EX to AX	---	---	---	87	87.00	1.00
Cementing	699.0	873.75	1.25-	600	900.00	1.50
Casing	788.0	394.00	0.50	no	charge	
Total "Extras"		$1,335.25	$0.60		$1,515.00	$0.41
Total drill and "extras"		$6,315.77	$2.82		$11,609.50	$3.13
Liquidated damages		80.00			none	
Total contract cost		$6,235.77	$2.78		$11,609.50	$3.13
Bureau Labor		$7,309.31	$3.26		$ 7,844.46	$2.12
Other Costs		1,736.25	0.77		1,516.13	0.41
Bureau Operating		$9,045.56	$4.04		$ 9,360.59	$2.53
Total Cost		$15,281.33	$6.82		$20,970.09	$5.66

Total Cost to Bureau under Southwestern Contract	$15,281.33	
Total Cost to Bureau under Sullivan Contract	20,970.09	
Miscellaneous Labor and Supplies	386.39	
	$36,637.81	$6.16 ft.
Supervision	5,064.75	0.85 ft.
Total Project Cost	$41,702.56	$7.01 ft.

$ 7.01 / 3.16 / 10.17

Expenditures by the Bureau of Mines in addition to sums paid the contractors, totaled $18,792.54, equivalent to $3.16 per foot of hole drilled. Of this amount, $15,491.46 ($2.61 per foot) was for labor employed in sampling, repairing underground workings, cutting stations, laying pipe lines, and miscellaneous odd jobs; $3,301.08 ($0.55 per foot) was for power, fuse, caps, dynamite, carbide, timber, pipe and fittings, miners lamps, and miscellaneous supplies.

Ore Reserves

The lower limit of minable ore is considered by the operators to be 1½ percent copper. On this basis calculations of tonnage in ore blocks indicated by Bureau drilling yield a total of 97,200 tons averaging 2.3 percent copper. Using a cut-off of 1.0 percent the tonnage would be 435,000 tons of 2.0 percent copper ore. A Summary of the tonnage estimates, showing ore blocks indicated by each hole that cut minable thicknesses of ore-grade mineralization, is given in the following tabulation.

Hole No.	Footage	Block No.	Size of ore block	Percent Copper	Tons, 1½% Cut-off	Tons, 1% Cut-off
3	84 - 120	A	30 x 60 x 80	3.49	12,000	12,000
	56 - 84	B	23 x 64 x 80	1.66		9,800
	56 - 74	B'	14½ x 65 x 80	1.87	6,283	
	11 - 36	C	20½ x 65 x 80	1.38		8,883
	16 - 21	C'	4 x 65 x 80	1.78	1,733	
	26 - 31	C''	4 x 65 x 80	1.50	1,733	
	Total				21,800	30,700
	Average % Copper				2.73%	2.29%
6A	7.6 - 28		19.7x 17 x 50	3.61	1,400	1,400
	Average % Copper				3.61%	3.61%
7	17 - 22	A	4½ x 50 x 50	2.61	938	938
	67 - 72	B	4½ x 50 x 50	1.78	938	938
	82 - 87	C	4½ x 50 x 50	1.55	938	938
	Total				2,800	2,800
	Average % Copper				1.98%	1.98%
13B	166 - 190	A	23x 50 x 80	2.04	7,667	7,667
	200 - 205	B	5 x 50x80	1.78	1,667	1,667
	208 - 217	C	8½ x 50 x 80	1.84		2,833
	212 - 217	C'	5 x 50 x 80	2.26	1,667	
(13A)	31 - 43)	D	7½ x 50 x 80	1.42		2,500
	22½ - 32½)					
(13C)	32 - 37)					
(13A)	192 - 200)	E	7 x 50 x 80	1.63		2,333
	150 - 159)					
	Total				11,000	17,000
	Average % Copper				2.03%	1.86%
13A	31 - 43	D'	9 x 20 x 50	1.63	750	
	192 - 200	E'	6 x 30 x 50	2.69	750	
	Total				1,500	
	Average % Copper				2.16%	
13C	182 - 197	A	12 x 50 x 100	1.22		5,000
	227 - 252	B	20 x 50 x 100	1.68		8,333
	237 - 252	B'	12 x 50 x 100	1.87	5,000	
	227 - 232	B''	4 x 50 x 100	1.59	1,667	
	255 - 272	C	13½ x 50 x 100	2.34	5,625	5,625
	301 - 309	D	5½ x 50 x 100	1.40		2,292

Hole No.	Footage	Block No.	Size of Ore block	Copper (Percent)	Tons, 1½% Cut-off	Tons, 1% Cut-off
13C (con.)	311 - 331	E	16 x 50 x 100	1.95		6,667
	311 - 326½	E'	12 x 50 x 100	2.16	5,000	
	370 - 376	F	5 x 50 x 100	1.07		2,083
	Total				17,300	30,000
	Average % Copper				2.08%	1.72%
14	80 - 87	A	7 x 50 x 80	1.74		2,333
	80 - 85	A'	5 x 50 x 80	2.03	1,667	
	91 - 95	B	4 x 50 x 80	1.25		1,333
	105 - 115	C	9½ x 50 x 80	2.13		3,167
	105 - 110	C'	5 x 50 x 80	2.89	1,667	
	127 - 164	D	35 x 50 x 80	2.08		11,667
	127 - 131	D'	4 x 50 x 80	1.95	1,333	
	139 - 164	D''	24 x 50 x 80	2.43	8,000	
	167 - 172	E	5 x 50 x 80	2.10	1,667	1,667
	177 - 187	F	9½ x 50 x 80	1.91		3,167
	177 - 182	F'	5 x 50 x 80	2.42	1,667	
	192 - 202	G	9½ x 50 x 80	1.73	3,167	3,167
	Total				19,200	26,500
	Average % Copper				2.25%	1.94%
15A	171 - 176	E	4 x 40 x 80	1.18		1,067
	181 - 196	B	6 x 40 x 40	1.81	2,400	2,400
	211 - 216	C	6 x 40 x 80			
			4 x 40 x 80	3.46	1,067	1,067
	235 - 240	D	4 x 40 x 80	1.13		1,067
	Total				3,500	5,600
	Average % Copper				2.30%	1.87%
15B	171 - 207	A	36 x 30 x 70	2.32	6,300	6,300
	Average % Copper				2.32%	2.32%
16	31 - 43½	A	8 x 70 x 70	1.59		3,267
	31 - 40	A'	6 x 70 x 70	1.70	2,450	
	48½ - 56	B	5 x 70 x 70	2.21	2,041	2,041
	Total				4,500	5,300
	Average % Copper				1.93%	1.83%
17C	26 - 48	A	21 x 45 x 50	2.47		3,938
	26 - 46	A'	19 x 45 x 50	2.59	3,562	
	61 - 75	B	13½ x 25 x 50	2.18		1,407
	65 - 74	B'	9 x 25 x 50	2.52	938	
	Total				4,500	5,300
	Average % Copper				2.59%	2.39%
17B & 17C	C - 5		4 x 12 x 60	2.30	200	200
	Average % Copper				2.30%	2.30%
18C	21 - 39½	A	17 x 30 x 50	2.10	2,125	2,125
	45 - 56	B	10 x 30 x 50	1.41		1,250
	50 - 56	B'	5½ x 30 x 50	1.63	688	
	Total				2,800	3,400
	Average % Copper				2.00%	1.78%
21	9½ - 21	A	10 x 20 x 30	2.19		500
	9½ - 19	A'	8½ x 20 x 30	2.43	400	
	Average % Copper				2.43%	2.19%
			TOTAL TONNAGE		97,200	135,000
			AVERAGE % COPPER		2.30%	2.01%

Assuming that 10 percent of the 97,200 tons of 2.3 percent copper ore will be left as pillars in extraction, the minable reserves added by Bureau drilling total 87,500 tons.

The exploitable areas now being mined contain not more than 10,000 tons that will average approximately 2 percent copper.

Drilling completed by the Harvey Mudd interests below the 770 level indicated an additional 34,500 tons of 2.42 percent copper. A tabulation of the indicated and estimated, recoverable mine reserves follows:

Developed reserves (estimated).....	10,000 tons of 2.0 percent
Reserves indicated by Mudd.....	34,500 tons of 2.4 percent
Reserves added by Bureau of Mines...	87,500 tons of 2.3 percent
Total reserves.....	132,000 tons of 2.3 percent

All of the ore indicated by the Harvey Mudd drilling and Holes 3, 6A and 7 of the Bureau of Mines lies below the 770 or lowest accessible working level and can be mined only by developing the 900 level, a major program not contemplated at present. Hence this ore is considered inaccessible as far as present operations are concerned. Dividing the reserves into two classes, accessible and inaccessible, the above tonnage may be split as follows:

ACCESSIBLE ORE
(above 770 level)

Developed reserves (estimated)....	10,000 tons of 2.0 percent
Reserves added by Bureau.....	64,100 tons of 2.2 do.
Total Reserves.....	74,100 tons of 2.2 percent

INACCESSIBLE ORE
(below 770 level)

Reserves indicated by Mudd.....	34,500 tons of 2.4 percent
Reserves added by Bureau.....	23,400 tons of 2.7? do.
Total reserves.....	57,900 tons of 2.5 percent

CALCULATION OF ORE RESERVES

Tonnages were calculated using both 1½ and 1 percent cut-off. Under present conditions, the mine operators claim that they can balance costs and returns on 1½ percent ore; hence this figure is the more logical one to use in determining reserves of ore suitable for mining at this time. Only the ore blocks resulting from application of the 1½ percent cut-off are included in the following discussion and calculations.

Hole 3 (fig. 10), which was drilled in the west finger country, indicated ore between 84 and 120 feet (Block A), between 56 and 74 feet (Block B'), between 16 and 21 feet (Block C'), and between 26 and 31 feet (Block C''). Experience has shown that in a bay formed by the main diorite intrusive and a finger, the mineralization is quite extensive. The heavily mineralized 773 bed as exposed in 773 drift, dips toward this bay and under 809 drift. This bed is exposed by the drift, some 170 feet south of the collar of hole 3 and it has been fairly well established that the mineralization extends all along the contact and into the bay explored by hole 3. Blocks 60 and 65 feet wide and 80 feet long were assumed for the ore zones shown in hole 3.

Block A $\frac{30' \text{ thick} \times 60' \text{ wide} \times 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 12,000 tons 3.49% copper

Block B' $\frac{14.5' \text{thick} \times 65' \text{ wide} \times 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 6,283 tons 1.87% copper

Block C' $\frac{4' \text{ thick} \times 65' \text{ wide} \times 80' \text{ long}}{12 \text{ cu. ft. per. ton}}$ = 1,733 tons 1.78% copper

Block C'' $\frac{4' \text{ thick} \times 65' \text{ wide} \times 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 1,733 tons 1.50% copper

or a total of 21,800 tons of 2.73% copper

Hole 6A (fig. 11), also drilled in the west finger country of the deposit, indicated ore between 7.6 and 28 feet, carrying 3.61 percent copper. Here the limits of the ore blocks are determined by the enclosing diorite and hole 5.

$$\frac{19.7' \text{ thick} \times 17' \text{ wide} \times 50' \text{ long}}{12 \text{ cu. ft. per ton}} = 1{,}395 \text{ tons of } 3.61\% \text{ copper}$$

or a total of 1,400 tons of 3.61% copper.

Hole 7 (fig. 10) drilled to test the westward extension of the ore shown in hole 3, indicated three ore zones, one between 17 and 22 feet, one between 67 and 72 feet, and one between 82 and 87 feet. Blocks 50 by 50 feet were assumed.

Block A $\frac{4\frac{1}{2}' \text{ thick} \times 50' \text{ wide} \times 50' \text{ long}}{12 \text{ cu. ft. per ton}} = 938 \text{ tons } 2.61\% \text{ copper}$

Block B $\frac{4\frac{1}{2}' \text{ thick} \times 50' \text{ wide} \times 50' \text{ long}}{12 \text{ cu. ft. per ton}} = 938 \text{ tons } 1.78\% \text{ copper}$

Block C $\frac{4\frac{1}{2}' \text{ thick} \times 50' \text{ wide} \times 50' \text{ long}}{12 \text{ cu. ft. per ton}} = 938 \text{ tons } 1.55\% \text{ copper}$

or a total of 2,800 tons of 1.98% copper

Referring to Figures 15 and 16, it will be noted that the stopes above the area prospected by holes 10, 11, 12, 13A, 13B, 13C, and 14 are fairly continuous along the contact but vary considerably in height. The average width of these stopes was found to be 50 feet. It was also noted from the plan that the stopes extend to the contact in some instances but, generally, the stope boundaries are some distance from the diorite. The varying thickness of the mineralization shown by the stoping was also indicated in the drill holes. The spacing of the drill holes was in part controlled by the accessibility of the workings, and the holes were too far apart to correlate intersections in adjoining holes with assurance. In some cases, there was boubt as to the stratigraphic correlation of the beds shown by drilling. For this reason, the ore blocks indicated by individual holes, although believed to lie in the same beds as ore blocks shown by other drilling, were not extended to adjoining holes.

Hole 13A- Block D'- $\frac{9' \text{ thick} \times 20' \text{ wide} \times 50' \text{ long}}{12 \text{ cu. ft. per ton}} = 750 \text{ tons of } 1.63\% \text{ copper}$

Hole 13A-Block E' - $\frac{6' \text{ thick x } 30' \text{ wide x } 50' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 750 tons 2.69% copper

or total of 1,500 tons of 2.16% copper

Hole 13B-Block A - $\frac{23' \text{ thick x } 50' \text{ wide x } 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 7,667 tons 2.04% copper

Block B - $\frac{5' \text{ thick x } 50' \text{ wide x } 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 1,667 tons 1.78% copper

Block C' - $\frac{5' \text{ thick x } 50' \text{ wide x } 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 1,667 tons 2.26% copper

or a total of 11,000 tons of 2.03% copper

Hole 13C-Block B' - $\frac{12' \text{ thick x } 50' \text{ wide x } 100' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 5,000 tons 1.87% copper

Block B'' - $\frac{4' \text{ thick x } 50' \text{ wide x } 100' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 1,667 tons 1.59% copper

Block C - $\frac{15\frac{1}{2}' \text{thick x } 50' \text{ wide x } 100' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 5,625 tons 2.34% copper

Block E' - $\frac{12' \text{ thick x } 50' \text{ wide x } 100' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 5,000 tons 2.16% copper

or a total of 17,300 tons of 2.08% copper

Hole 14-Block A' - $\frac{5' \text{ thick x } 50' \text{ wide x } 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 1,667 tons 2.03% copper

Block C' - $\frac{5' \text{ thick x } 50' \text{ wide x } 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 1,667 tons 2.89% copper

Block D' - $\frac{4' \text{ thick x } 50' \text{ wide x } 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 1,333 tons 1.95% copper

Block D'' - $\frac{24' \text{ thickx50' wide x } 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 8,000 tons 2.43% copper

Block E - $\frac{5' \text{ thick x } 50' \text{ wide x } 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 1,667 tons 2.10% copper

Block F' - $\frac{5' \text{ thick x } 50' \text{ wide x } 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 1,667 tons 2.42% copper

Block G - $\frac{9\frac{1}{2}' \text{ thick x } 50' \text{ wide x } 80' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 3,167 tons 1.73% copper

or a total of 19,200 tons of 2.25% copper

Hole 15A (fig. 20) drilled to prospect below 508 stope, encountered ore from 181 to 196 feet (Block B), and from 211 to 216 feet (BlockC). The first ore zone is thought to be an extension of 508 stope below the level with the lower part of the zone lying in the bottom of the stope. As the thickness of the ore was 12 feet, 6 feet was assumed to be comparable to that part mined by 508 stope and the bottom 6 feet to be the unmined portion below the stope. A block 6 by 40 by 40 feet was assumed for the upper half of the bed and 6 by 40 by 80 feet for the lower half. The extent of the ore indicated between 211 and 216 feet was assumed to be comparable to that in the overlying Block B, and the dimensions 40 by 80 feet assigned to it.

$$\text{Block B}\left\{\begin{array}{l}\dfrac{6' \text{ thick} \times 40' \text{ wide} \times 40' \text{ long}}{12 \text{ cu. ft. per ton}} \\ \dfrac{6' \text{ thick} \times 40' \text{ wide} \times 80' \text{ long}}{12 \text{ cu. ft. per ton}}\end{array}\right. = 2,400 \text{ tons } 1.81\% \text{ copper}$$

$$\text{Block C} - \frac{4' \text{ thick} \times 40' \text{ wide} \times 80' \text{ long}}{12 \text{ cu. ft. per ton}} = 1,067 \text{ tons } 3.41\% \text{ copper}$$

or a total of 3,500 tons of 2.29% copper

Hole 15B (fig. 20) was drilled vertically to prospect the Las Novias series below 412 stope. Mineralization of ore grade was found between 171 and 207 feet. The average width of 412 stope was found to be 40 feet and the length to be 125 feet. An ore block measuring 30 by 70 feet was assigned to the ore zone shown by drilling.

$$\frac{36' \text{ thick} \times 30' \text{ wide} \times 70' \text{ long}}{12 \text{ cu. ft. per ton}} = 6,300 \text{ tons of } 2.32\% \text{ copper}$$

Hole 16 (fig. 21), the first of the holes to be drilled during the "short hole" program to locate readily accessible ore, indicated mineralization of ore grade in the 85 bed between the footages 31 - 40 and 48.5 and 56. Old assay records show unmined ore occurring in 414M raise in 414 drift to the east of hole 16. The 50 and 85 beds have

been partly mined from 414H raise but the dip of the beds and low grade of the ore discouraged further mining down the dip of the area prospected by hole 16. This stoping had been done on the outer limits of the ore zone where the grade drops before playing out. After hole 16 was completed, 428 drift was extended parallel to the hole and a raise driven to open the ore indicated. Samples taken in the raise showed the assays in the hole to be low. Blocks 70 feet long by 70 feet wide were assumed, which is conservative in view of the indications of widespread mineralization.

Block A'- $\frac{6' \text{ thick x } 70' \text{ wide x } 70' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 2,450 tons of 1.70% copper

Block B - $\frac{5' \text{ thick x } 70' \text{ wide x } 70' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 2,041 tons of 2.21% copper

or a total of 4,500 tons of 1.95% copper

Holes 17A, 17B, and 17C (fig.22) were drilled from 424A stope to test the potential productivity of the 50 and 85 beds to the west of hole 16. All three holes showed four feet of ore in the bottom of the stope. In 424A stope, only that immediate area from which the holes were drilled is accessible. Because of this, the mineable portion of the ore left in the bottom of the stope was confined to a block measuring 12 by 60 feet. Hole 17C showed ore in the 50 and 85 beds between the footages 26-46 (Block A') and 65-74 (BlockB'). In this case the size of the ore blocks was determined by enclosing diorite and fault structures.

Block A' - $\frac{19' \text{ thick x } 45' \text{ wide x } 50' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 3,562 tons 2.59% copper

Block B' - $\frac{9' \text{ thick x } 25' \text{ wide x } 50' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 938 tons of 2.52% copper

The bottom 4 feet of the stope will add to this:

$\frac{4' \text{ thick x } 12' \text{ wide x } 60' \text{ long}}{12. \text{ cu. ft. per ton}}$ = 240 tons of 2.30% copper

or a total of 4,700 tons of 2.57% copper

Hole 180 (fig. 23) drilled from 458 stope to explore the 50 and 85 beds, intersected ore between 21 and 39.5 feet (Block A) and between 50 and 56 feet (Block B'). Dimensions 30 feet wide by 50 feet long, which is 60 percent of the area of the overlying stope, were assigned to these ore blocks.

Block A - $\frac{17' \text{ thick} \times 30' \text{ wide} \times 50' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 2,125 tons of 2.10% copper

Block B' - $\frac{5.5' \text{ thick} \times 30' \text{ wide} \times 50' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 688 tons of 1.63% copper

or a total of 2,800 tons of 2.00% copper

Hole 21 (fig. 25) drilled from 412 drift located the up-faulted side of the extension of the ore mined in 412 stope. Arbitrary dimensions of 20 feet wide by 30 feet long were given to this ore block.

$\frac{8.5' \text{ thick} \times 20' \text{ wide} \times 30' \text{ long}}{12 \text{ cu. ft. per ton}}$ = 400 tons of 2.43% copper

MINING AND MILLING METHODS

Description of Mine Workings

Although there are five shafts on the property, only No.3, the present working shaft, is in usable condition. This shaft has two hoisting compartments and one pipe and manway compartment, and is equipped with a double drum hoist, powered by a 150-horsepower electric motor. Two electric, belt-driven compressors, one 625 c.f.m. and one 1800 c.f.m. capacity, are located in the hoisthouse. Compressed air is supplied to the underground workings through a 4-inch shaft column with 2-inch take-offs on each level. Other surface equipment is housed in a machine shop, a blacksmith shop, a framing shed, and a warehouse. All hoisting is being done with a single deck cages. There are no shaft or skip pockets.

The main levels are the 100 (bulkheaded), 200, 300, 400, (mill haulage level), 500 (bulkheaded), 635, 770, and 900 (flooded). Water

stands at the 770 level in No. 3 shaft, which is 908 feet deep. The 300 level is open to the surface at both ends, and is used for the passage of men but not equipment or supplies. The 400 level is connected to the surface by the Mill Haulage Drift which is used to transfer mine ore to the mill bins in ten 3-ton cars hauled by a 3-1/2-ton battery locomotive. All ore mined above the 400 level is dropped to that level by transfer chutes. Ore mined below the 400 level is hoisted to the 300 in 3/4-ton mine cars, trammed to transfer chutes by a battery trammer, and dropped back to the 400 level where it is picked up by the mill haulage train.

The large number of openings to the surface provide adequate natural ventilation above the 400 level. Below the 400 the workings are ventilated by electrically-driven blowers.

Above the 400 level the workings have been thoroughly drained. The ground having settled and adjusted itself before mining, little timber support has been required in this area. Below the 400 level seepage of surface water and of water introduced into the mine for drilling causes the ground to cave in some areas, requiring considerable timbering and maintenance. Nowhere in the mine is the ground extremely heavy and only in drifts through gob was crushing of the timbers noted. However, after exposure to the air for a time, there is a tendency toward sloughing which accounts for the inaccessibility of some of the workings.

Between 35,000 and 40,000 gallons of water per day are pumped from the 770 level station. Some of this water is retained in tanks for redistribution to working faces and the remainder discharged at the surface.

Development

Development drifts and crosscuts, 5 by 7 feet in cross-section, are driven by column-mounted drifters. Before October, 1943 all mucking

in drifts was done off the rough by hand. Since that time a mine car loader has been purchased which has speeded development considerably. Probably 20 percent of the drift development footage requires timbering, especially through and in the vacinity of the diorite contacts and fault zones. The principal development at present is extension of the 635 level along the south contact to open the ore reserves shown by Bureau drilling in Holes 13A, 13B, 13C, 14, 15A, and 15B. The ore cut in Holes 16, 17C, 18C, and 21 is being developed from the 400 level.

Raises are driven 10 by 6 feet in cross-section and are composed of a chute and manway. The majority are timbered with square sets, although some stulled raises have been driven, with chute and manway separated by stulls and lagging.

In the ideal development of an ore body at the Christmas mine, a drift is driven in the sediments parallel to the diorite contact and about 10 to 20 feet from it. A raise is driven into the ore zone and stoping started. As the stope faces advance, other raises are driven from the drift, holing the stope as close as possible to the working face. The interval between these raises varies from 30 to 100 feet, the controlling factor apparently being the distance of the ore body above the drift.

Mining Methods

Room-and-pillar, shrinkage, cut-and-fill, and square-set stoping all have been employed in extracting ore from the Christmas mine. However, the last three methods have been utilized only on a limited scale. Most of the ore is too low grade to bear the cost of square-setting. The beds in general are too flat and too thin for shrinkage stoping. Cut-and-fill requires the use of gob which, according to the management, is too expensive to place into the stopes. This method of mining would be advantageous in some areas if waste were

devised to obtain and deliver waste fill to the stopes economically. The stoping areas on the different levels are so situated that they could be connected by raises, and in most cases such connections exist. A switch to cut-and-fill stoping in stopes now active would be feasible if cheap gob were available. In the area between the 635 and 400 levels explored by Holes 13A, 13B, 13C, and 14 and now under development, raises could be driven from the 635 level to Hole 530A raise on the west of the section and 512A raise on the east (fig. 19). Gob could be delivered through these raises from the 400 level to the working stopes above the 635. A means of transfer on the 500 might be necessary and could be accomplished by scrapers, tramming, or finger chutes. As a possible means of obtaining gob, rill stopes might be started in the diorite above the two raises mentioned. In some places in the mine where the diorite has been opened it has been found that, unless cribbed, the diorite will continue to cave and slough. In such areas, gob could be obtained very cheaply, and the cost of filling the stopes with waste would be partially offset by recovery of ore that otherwise would be left as pillars. Some fill would also be obtained from barren sediments included between the ore-bearing strata.

However, under present conditions, the room-and-pillar method of mining has been accepted as the most economical. This method is well adapted to the attitude of the beds which dip$^{\pm}$ 10°. The stope height varies from 7 to 60 feet, averaging about 15 feet. The stope widths vary from 20 to 100 feet, averaging between 50 and 55 feet. Pillars are spaced 25 to 35 feet apart, the interval depending upon the character of the stope walls and back and to some extent on the grade of the ore. In stopes requiring a heading and

one cut, the heading is driven on the bottom of the ore and the cut taken out of the back. Where more than one cut is needed, heading and benches are used.

In past mining operations, ore was handled in the stopes with wheelbarrows and in few cases, track was laid and the ore transported in 3/4-ton mine cars. Recently two double drum air hoists were purchased and scraping has been tried with satisfactory results. The present trend in mining operations at Christmas mine is toward mechanization in handling muck. The resulting increase in output per man tends to compensate for the shortage of competent miners from which the operation has suffered.

Mill Description

The Christmas mill is not operating at the present time. It was designed and built by the Southwestern Engineering Company in 1928. Crushing and grinding equipment consist of a gyratory primary crusher, a 4-foot Symons cone crusher and two Cole-Bergman, 5 by 10-foot ball mills in closed circuit with rake classifiers. The two independent flotation circuits composed of Southwestern pneumatic cells have a capacity of 250 tons each. Recovery is reported to have been in excess of 90 percent of the sulfides and 50 percent of the oxides. The concentrate was piped to an Oliver filter plant on the railroad below the mill. The mill flow sheet will be found in Appendix 7.

CONCLUSIONS

The Bureau of Mines drilling program has indicated enough ore to maintain production of 3,000 tons per month for a period of two years. Estimates of reserves are felt to be conservative. Past experience in mining these ore bodies supports the belief that the

areas prospected probably will yield considerably more than the calculated tonnage of ore.

The best ore cut by the drill holes is below the 770 level and can be mined only if proposed 900-level development is carried out. This would involve unwatering the shaft, extending the 900 level some 500 feet northeasterly from No.3 shaft, and crosscutting and raising from this level to give access to the indicated ore bodies. Approval of this program by the War Production Board was later withdrawn because of manpower shortage.

The depth of the deposit has not been determined, but it is possible that as much ore will be found below the 770 level as has been mined above. Several hundred feet of potentially favorable sediments, including formations that have proven productive elsewhere, are believed to lie below the deepest mine workings.

Christmas mine file
6/11/09.

CONFIDENTIAL

MR. LOUIS KOBLE'S REPORT
ON THE
SAMPLE MOUNTAIN PROPERTY

The geology of the district has been most carefully studied by Mr. T. W. Brooks, who in turn availed himself of the exhaustive investigations of the U. S. Geological Survey in the adjacent Globe District, so that as far as geological theories and analogies are of value, the situation is thoroughly understood. As I am approaching the matter purely in its commercial aspect, I will state in their simplest form only the geological facts which have a bearing on the occurrence of ore.

The lowest rock in which we have an interest is the Cambrian Quartzite, which is exposed extensively in Schneider Canon. At many points it shows prominent copper staining, and in the various shallow workings considerable amounts of 3% and 4% quartzite ore is exposed. This material is an ideal one for converter linings, and while no tonnage is shown by systematic development, the many scattered occurrences of this material assure an ample supply for all such requirements.

Lying above the quartzite is a thickness of probably 1200 feet of alternating limestones and shales, the former predominating, and above these a once continuous flow of andesite caps the hills except where removed by erosion. The whole sedimentary series with the andesite has been extensively faulted, and now presents on a large scale a series of prisms packed together at different degrees of elevation with respect to each other. So that in passing along the surface, changes of geological horizon of several hundred feet will occur as these faults are crossed. Finally a series of generally vertical porphyry dykes cut the entire formation including the andesite. These dykes systems extend for several miles and are most irregular in outline, swelling at times to a width of several hundred feet and

sending out many tongues. All of the ore occurrences of importance have been found adjacent to these dykes in such beds of limestone as proved hospitable either by reason of composition or through shattering, and in these beds the ore continues frequently for considerable distances away from the porphyry contact.

The ore consists of altered limestone usually garnetized and containing chalcopyrite and in a minor degree other copper minerals. In a broad sense, all the replaced limestone is geological ore, and its extent is exceptionally great. We are interested only in that portion of it which contains over 2% copper and is commercial ore. The proportion of the mass of mineralized material which belongs to the latter class can only be judged where extensive development has been done, and will be better understood from the following description of the workings on The Caddie Mountain property and the results of our sampling.

The heaviest mineralization so far disclosed is in the vicinity of No. 1 shaft. An outcrop known as Copper Knob shows a body of material 200' by 58' in plan, which by our sampling averages 3.21% copper. This is in the form of a thick sheet dipping at 30° southerly. The vertical thickness of the bed will be about 30 feet, and its downward extension into the hill is not explored in any way as far as I can see, and might produce important tonnage. A considerable tonnage has been mined here by open cut, but there remains standing and measurable about 29,000 tons.

Below this about 100 feet is the Jenny stope, which is opened by tunnels from surface. A large tonnage has been mined from this stope, which covers an area irregularly 500 feet long by 100 to 150 feet wide. The many pillars left show average grade ore but could not profitably be removed. At the west end of the stope, a thickness of 7-1/2 feet

of ore shows for a distance of 50 feet, and averages 3.27% copper. We can safely estimate here 1,000 tons.

In the ground between the Jonny stope and the Copper Knob, two other ore horizons are known, but the lateral extent of workings is not great on either. It would be a quick and promising piece of exploration work to investigate these by upraises from the Jonny stope. The first is known as the lower Copper Knob body, which shows a surface outcrop 80 feet long and 12 feet thick, averaging 3.44% copper. A tunnel shows the continuation of this into the hill for 25 feet, beyond which point it is faulted. The probable tonnage here is 2,000.

Some 25 feet below this, the Jonny intermediate stope has been opened by upraise from the Jonny stope proper. It is a stope of small area 20 by 40 feet, showing ore on all sides, and is most promising, having possibilities of the same extent as the Jonny stope. Samples around this stope averaged 3.03% copper.

Below this Jonny stope for 150 feet no important ore horizons are found until the 300 foot level is reached. On this level the Las Novias stope has been worked extensively, and a large tonnage is still left below the floor of the level. The Las Novias stope is irregular in outline but averages 200 feet by 80 feet in plan, with a breast over 30 feet thick and 80 feet wide still in good ore. A total thickness of 65 feet is shown for this body by a winze near its southerly end, and a probability of 40,000 tons of ore below the present floor of the stope is indicated.

A reasonable expectation of ore from the continuation of the body now disclosed at the end of this stope, is 5,000 tons. I believe, however, that by judicious development to the crest of the present stope, much larger tonnage will be opened.

The average grade of samples taken in the face above referred to, is 4.09% copper. The average grade of the winze from the 500 foot level to the bottom of the ore body 60 feet below, is 5.12% copper. This is distinctly the best and largest ore body so far opened on the property, and its character for smelting is more desirable than anything disclosed in the upper levels.

The ground opened on the 400 foot level is in general unpromising. What appears to be the top of an ore body is shown for a length of 25 feet, but until a winze is sunk in it no judgment of its extent can be formed. Otherwise the level appears to be in a barren zone.

A small sump extends below the 400 level. The water flow is not important.

Summing up the indicated ore reserves in this section we find 80,000 tons, which will average better than 5% copper. These reserves are not strictly blocked out, but they exist without question, and a small amount of additional work would readily prove them and add to them.

The detail of sampling on which the above conclusions are based is shown on the blue prints accompanying. The samples were all evenly cut grooves in general running diagonally down faces, so as to avoid the error of following vertical or horizontal banding, both of which were at times visible.

The copper determinations were made on the ground by my assistant, and the pulps brought to Denver and checked by Von Schulz & Low.

In addition to the five ore horizons, aggregating a thickness of 117 feet in ore, shown in a depth of 600 feet, there are other orebodies lying along contacts and fissured zones. These are irregular and not extensive. In many cases they will pay tostope if encountered in the course of development work, but are not worth prospecting for per se.

The workings of next importance are situated about 1,000 feet northeasterly from No. 1 shaft, and are known as the Hackberry. They consist of several tunnels and a shaft. A good body of ore was encountered near the shaft and partially worked out. Its dimensions are 180 by 50 feet horizontally with an average thickness of 10 feet. Water now covers the portion of the stope where ore was left standing. Three other smaller bodies were encountered in drifting, only one of which is now accessible for sampling. This shows in a tunnel for a length of 60 feet, averaging 2.8% copper. No work is done to show any but the one dimension, so that no estimate of tonnage can be made, but from the general heavy mineralization in this locality I believe that the Hackberry ground will prove important in production.

Between the No. 1 workings and the Hackberry, a fault is crossed, and the Hackberry block has been raised with reference to the No. 1 block of ground, which places this Hackberry ore at a much lower horizon geologically than the Las Novias ore body, and hence furnishes good grounds for the belief that further sinking in the No. 1 district would show other ore bodies.

The Christmas workings constitute the development of next importance. They are located on the southerly side of the porphyry intrusion, the No. 1 and Hackberry being north of it and distant about half a mile from the Christmas.

A series of open cuts from which tunnels and inclines have been run, constitute these workings, and there is evidence of the extraction of a large amount of ore. Faulting is prominent, and while some of the outcrops are very impressive, the grade of ore and probability of continuous bodies is less favorable than in the other localities considered. One measurable body is shown by open cut and tunnel containing 7,000 tons of 2.5% ore. 125 feet below this working and 200 feet below the highest of the open cuts, the lower Christmas tunnel has been run a distance of about 900 feet. It shows one ore body 60

by 150 feet in plan, with a disclosed thickness of 7 feet and amounting to 4,500 tons, averaging 1.96% copper. The general showing in the tunnel aside from this is poor.

The Christmas locality as a whole shows large bodies of geological ore, and although a very large amount of work has been done, very little commercial ore has been found. My opinion is that The Saddle Mountain Company has in the past made a mistake in mining and smelting large quantities of this ore, which could not have paid, but they were doubtless attracted by the facilities for cheap quarrying operations.

The andesite capping is not far from the upper Christmas open cuts, hence it is evident that all of those operations were in the upper line horizons, and I consider that by sinking in this heavily mineralised section, the chance for better ore bodies would be good.

As to future development, we have seen that there are 60,000 tons of ore practically in sight. I believe that a small amount of additional work will prove this ore thoroughly, and open 20,000 tons more in the extensions of the known bodies. The most promising direction in which to look for new bodies is below the No. 1 and Huckberry workings, and in the unexplored territory lying westerly from No. 1 shaft. After that comes the possibilities by sinking in the Christmas section. The ore production made by the Saddle Mountain Company was 115,300 tons, which was not separated as to localities. I conclude from size of stopes that 75,000 tons of this came from the No. 1 workings. Adding this to the 100 tons likely to be produced within the 400 feet of depth so far developed, we have a fair idea of the productiveness of favorable ground per 100 feet of depth, namely: 44,000 tons.

Working on this basis, and taking into account all the localities where prospecting would be justified, it seems reasonable to me to expect that from 500,000 to 1,000,000 tons of ore might be developed on this property, and

that an expenditure of $100,000 would accomplish it. I do not state this as the ultimate possibility of the property but as representing what could fairly be hoped for on present appearances.

I would advise if this work is to be undertaken that the No. 3 shaft be equipped with the hoist now lying at Winklemen, and that connection be made with the 300 foot level of No. 1 shaft, and work continued both in the breast of the Las Novias stope and also along the basalt dyke at the south side of that stope and that this work be carried forward to the Hackberry orebodies. I would also advise exploring westerly both from the Jonny stope and also the 300 foot level; also proving the extent of the Jonny intermediate stope by upraises from the Jonny stope. The No. 3 shaft should be sunk and crosscuts run to the productive sections at 100 foot intervals. No. 1 shaft will have to be abandoned, as it is too small to continue downward if water is to be handled. No. 3 shaft is 280 feet deep, well timbered with 3 compartments each 4 x 5 feet in the clear. It is sunk in porphyry, but seems to be standing well.

Before undertaking deep development on the Christmas, I would recommend testing that ground by churn drills.

In order to judge of the smelting qualities of these ores, I have made from our samples, mixtures representing average composition for the different localities. The analyses of these by Von Schulz & Low are as follows:

Locality	Cu.	SiO_2	FeO	CaO	S
Christmas surface ore	2.33	27.92	24.03	25.34	0.93
Lower Christmas Tunnel	2.22	26.90	19.28	29.02	1.73
Surface Copper Knob	3.22	34.62	25.84	21.57	0.44
Las Novias Breast	4.18	28.8	25.92	20.72	4.87
Las Novias Winze and sublevel	3.76	37.8	18.96	17.82	5.85

It will be seen that the sulphur contents of the surface ores is insufficient to form matte, but by mixing with the deeper ores this percentage can be kept between 2 and 3, which will be sufficient.

A comparison of the above analyses with that of the self fluxing ore of Granby, B.C., will be of interest. This is as follows:

Insoluble	40%
FeO	19.35
CaO	20
Al_2O_3	7
MgO	7
S	3.5
Cu.	1.

The slag losses at Granby were reported to be 6 lbs. per ton.

The Granby slags were considered to be at the maximum silica limit, and it is evident that in this respect the Saddle Mountain composition has a safe margin, and with the variety of ores existing on the property it will be possible to vary composition of the smelting mixture to an extent which is not possible at Granby.

The precious metal contents at Granby is I believe $1.50 per ton. Their cost to produce copper was 6¢ per lb. on an operation of 3600 tons per day. In the matter of natural advantages the Granby has in its favor cheaper power (a good water power on the Pettis River), cheaper coke, larger ore-bodies admitting of open cut mining and requiring very little development expense and permitting a very large scale operation.

The Saddle Mountain has a better self fluxing composition, a higher value of metal contents, a shorter transport (but perhaps more expensive) between mine and smelter.

The mining and smelting operations of The Saddle Mountain Company we conducted from August 1905 to August 1907. The mining was not badly done, but cheaper costs could have been realized by using machine drills and by better

system of handling material. During this period 115,532 tons of ore were treated, producing 4,464,575 lbs. of copper, 27, 065 oz. of silver, and 704 o of gold. They produced and sold copper matte running from 50 to 65% copper. The average slag contained .475% copper, 56.5% SiO_2, 27.5% FeO, and 31% CaO.

The average recovery per ton of ore treated was 39.571 lbs. copper, 0.25801 ozs. silver and .006918 oz. gold. Adding the slag loss to the copper recovery, we find that the ore smelted averaged 49.03 lbs. to the ton of 2.4% copper. The average value of precious metal recovered was $.263 per ton.

In estimating the profit which can be realized in mining and smelting these ore bodies, I assume that the ore will be broken by machine drills, and that on the thicker ore bodies levels will be run at the bottom, upraises put through, and the ore stoped underhand through these raises; that a good hoisting equipment will be provided, and that the ore will be conveyed by wire rope tram to some point on the Gila River, whence it will go by rail to the smelter.

I estimate costs under these conditions as follows:

Mining and hoisting	$3.00 per ton	
Tramway	.10	
Railroad	.25	
Mine administration and general	.15	$1.50
Smelting,		3.00
Total		$4.50

The cost of shipping, refining and selling the blister copper produced, is estimated at $1.85 per lb., so if copper is assumed at 13 cents, the value per pound at the mine will be 11.75 cents. Assuming a 5% ore, we would have 60 lbs. of copper, less 9 lbs. loss in smelting, equals 52 lbs. copper at 11.75 cents equals $6.11

Gold and Silver,	.26
	$6.37
less mining and smelting,	4.50
PROFIT	$1.87

Cost per pound to produce equals ----------9.4 cents.

On 2-1/2% ore, the profit would be 7? cents per ton and the cost of production would be 11.33 cents per pound.

No development is included, except that necessary to extract the ore after the ore bodies have been found.

(Signed) Louis T. Noble.

Denver, Colo.,

June 1st, 1909.

June 9, 1941

Christmas Copper Corporation
29 West Street
Beverly Farms, Massachusetts

Attention: Mr. Roland H. Knight

Gentlemen:

I want to thank you for your letter of June 4 sending us the completed questionnaire regarding the potential copper production from the Christmas Copper Corporation in the event the government requires the copper and is willing to make the proper financial arrangement to bring it out. We feel very sure that this situation is going to come about.

We believe that the Christmas Copper Corporation is one of the potential producers in Arizona, but, of course, it could not work on 12¢ copper and still take care of the investment necessary to get it under way for large scale operations.

Thanking you again, and with kindest personal regards, I am

Yours very truly,

Chairman, Board of Governors
Arizona Department of Mineral Resources

CFW:LP
Enc.

CC: F.P.Knight, Jr.

June 11, 1941.

Mr. Roland H. Knight,
Christmas Copper Corporation,
29 West Street,
Beverly Farms, Mass.

Dear Mr. Knight:

I want to thank you for your letter of the 9th calling our attention to the conflicting statements on the two questionnaires. We will see to it that the report properly takes care of this feature.

Thanking you and with kindest personal regards, I am

Yours very truly,

Chairman, Board of Governors
Department of Mineral Resources.

CFW-M

May 29, 1941

Mr. Frank Knight, Jr.
Christmas Copper Co.
Winkelman, Arizona

Dear Frank:

We have not heard from you yet regarding the questionnaire that we sent you regarding potential copper producers, and I am particularly anxious that the Christmas Mine be included in our report as we regard it as one of the most important potential copper producers of the state.

I presume that the reason we have not yet heard is that there is quite a lot of figuring to be done in making out the report and that you are getting to it as fast as you can, but I rather feared that my first communication to you did not get there so I am sending you another.

We have information that leads us to believe that we are going to make some kind of a proposition with the government that will permit the marginal mines to work. I am also enclosing another questionnaire on which I would like the data asked for, as we propose to include within this report a brief statement regarding each property that is listed as a potential producer.

Hoping to hear from you soon, and with kindest personal regards, I am

Yours very truly,

Chairman, Board of Governors
Arizona Department of Mineral Resources

CFW:LP
Enc.

CHRISTMAS COPPER CORPORATION

CHRISTMAS, ARIZONA

via Winkelman

July 6, 1940.

Mr. J. S. Coupal, Director,
Department of Mineral Resources,
Capitol Building,
Phoenix, Arizona.

Dear Mr. Coupal:

Returning from fishing trip - which I hated to do - I find your letter of June 11th, and thank you for passing us the information. Have heard nothing from Mr. Matson.

Enclosed is copy of recent report on the Christmas Mine by Harrison Schmitt of Silver City, New Mexico. If you can find the time, I wish you would look it over before filing it with our report to your department. It would have been helpful had you had knowledge of its contents when writing Mr. Matson. Better yet would have been a report by Newt, and I hope he can get around to us before long. I know of no other property in the State that offers as good promise of putting 300 men to work, at least as quickly as this one.

With kindest regards.

Yours very truly,

F. P. Knight Jr.

Vice Pres.

FPKJr.

CHRISTMAS COPPER CO., Sam Knight, Lessee. Windlemen, Arizona.

This mine has been producing and shipping raw ore to the Hayden plant of the A. S. & R. Co., 639,200 pounds of copper being produced from January 1 to October 1, 1942. The average copper content has been 2.5%. The silicious nature of the ore is such that the smelter welcomes shipments in the amount of 1000 tons per month.

With some remodeling the 500 ton concentrating plant now intact but idle could be put into operation treating approximately 12,500 tons per month and producing 400,000 pounds of copper. This in excess of the 50,000 pounds being delivered directly to the smelter. No estimate can be made as to total potential production as tonnage is unknown.

Finances to remodel mill and for operating capital is required. The labor problem would follow as the present 50 man crew would have to be expanded considerably.

Report by Earl F. Hastings, October 9, 1942 to Copper Branch, War Production Board.

DEPARTMENT OF MINERAL RESOURCES

News Items

Date 6/16/39

Mine Christmas

Location Christmas, Ariz.

Owner Christmas Copper Corporation.

Address Winkleman

Portion of property under lease to

Operating Co. C.B.Hanraty

Address Christmas

Pres.

Genl. Mgr. F.P. Knight Jr.

Mine Supt.

Mill Supt.

Principal Metals Copper (little gold & silver)

Men Employed

Production Rate About 80 tons per day

Mill, Type & Capacity

Power, Amt. & Type

Signed W. H. Leith

(Over)