Bureau of Mines
Report of Investigations 5245

# LABORATORY CONCENTRATION OF VARIOUS ALASKA COPPER ORES

BY R. R. WELLS

United States Department of the Interior — June 1956

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UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary
BUREAU OF MINES
Thos. H. Miller, Acting Director

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by

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## INTRODUCTION AND SUMMARY

This report summarizes the results of preliminary mineral-dressing studies by the Bureau of Mines on five samples of copper-bearing ore from various Alaska deposits. The work on each sample was not extensive enough to warrant individual publication. The results, however, indicate the possibilities and limitations of concentration of the respective ores. The information therefore may be helpful in future development of these ore bodies.

Four of the five samples tested were submitted to the laboratory by engineers of the Bureau of Mines as part of the examinations and survey investigations of strategic-mineral deposits in Alaska. This program is conducted to assist development of mineral resources in the Territory and particularly to aid economic exploitation of marginal or complex ores. The fifth sample was submitted by engineers of the Defense Minerals Exploration Administration.

A sample of ore from the Moth Bay mine, Revillagigedo Island (fig. 1, item 1), contained 7.35 percent Zn and 1.62 percent Cu. The ore was found to be amenable to concentration by standard selective flotation methods to produce marketable copper and zinc concentrates with reasonably good recoveries.

A composite sample of ore from the Threeman mine, Port Fidalgo area, Alaska (fig. 1, item 2) contained 1.65 percent Cu. Flotation of a rougher concentrate from ore ground to minus-48-mesh, followed by regrinding and cleaning of the rougher concentrate, recovered 81 percent of the total copper at 28.4 percent Cu grade.

Two samples of arsenic-bearing, low-grade copper ore were obtained from the Golden Zone mine near Colorado Station, Alaska (fig. 1, item 3). By selective flotation of 0.97-percent Cu ore from the upper level, 82 percent of the copper was recovered in a concentrate that assayed 26.6 percent Cu; similar treatment of 0.24-percent Cu ore from the lower level recovered 67 percent of the copper in a concentrate that assayed 13.4 percent Cu.

Ore from the Kathleen-Margaret prospect, Maclaren River, near Paxton, Alaska (fig. 1, item 4), contained only 1.2 percent Cu but was readily amenable to beneficiation by standard flotation procedures. Over 95 percent of the copper was recovered in a concentrate that assayed 36.7 percent Cu.

## METHODS OF CONCENTRATION

During the investigations many data were obtained and compiled. For the sake of brevity, however, data of secondary importance have been omitted or condensed; only the tests that give the more promising results are discussed in detail.

Evaluation and concentration methods employed during the studies conformed with standard laboratory practices. Representative portions of each sample were subjected to petrographic study and were analyzed by both chemical and semiquantitative spectrographic methods. In no case, however, did the spectrograph reveal the

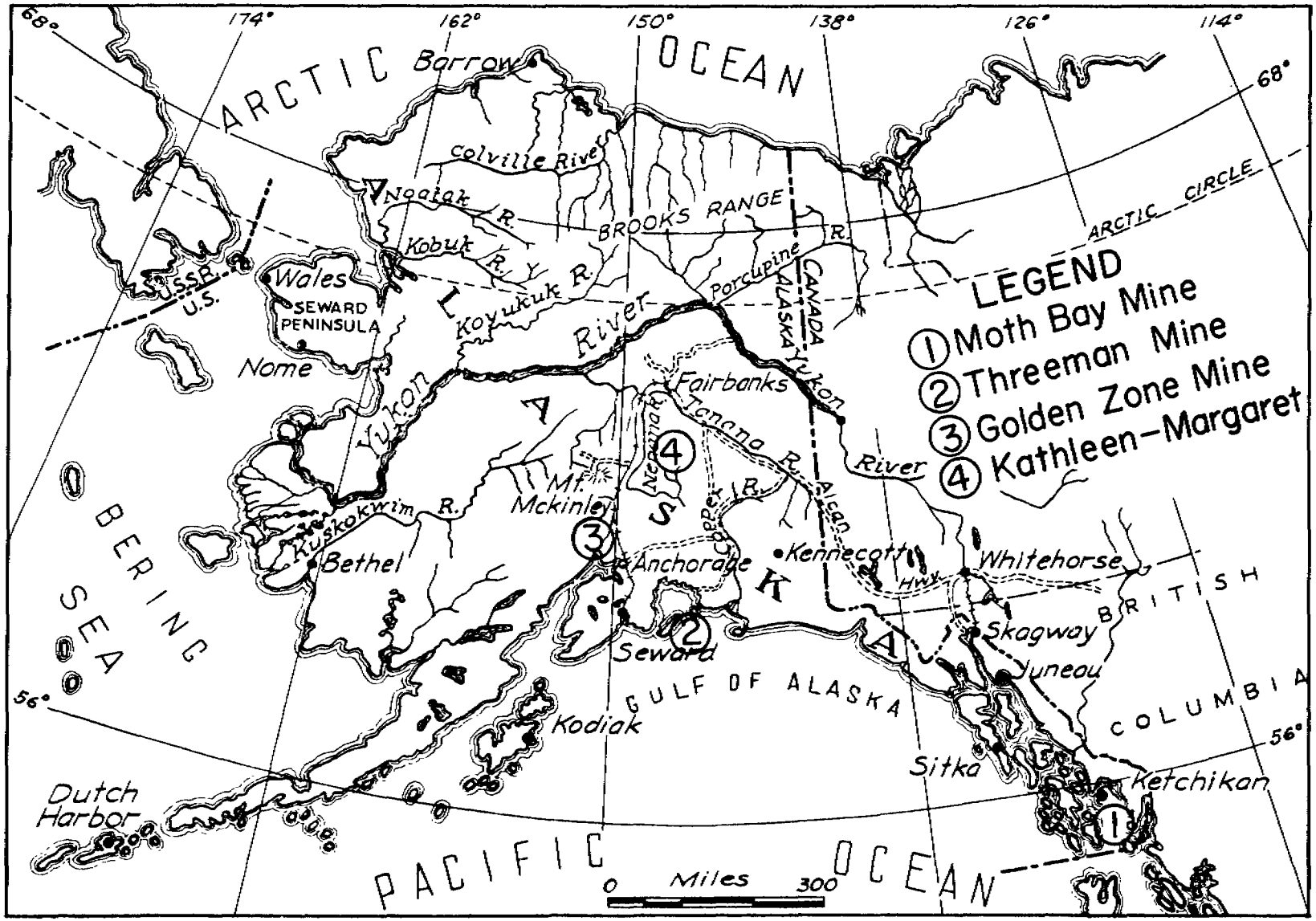


Figure 1. - Index map of Alaska.

presence of significant amounts of elements other than those reported by chemical means; therefore, the spectrographic data have been omitted from this report. Similarly, screen analyses of crushed portions of each ore showed no significant concentration of valuable mineral in a particular size fraction; consequently, the data from these tests also have been omitted. The fine-grained nature of all the ores tested necessitated relatively fine grinding for adequate mineral liberation. Although gravity-concentration techniques were employed in preliminary tests of some ores, flotation concentration yielded superior results; therefore no gravity-test data are included.

For convenience and clarity in presenting data, this report has been divided into four sections, each of which presents the results of laboratory study of samples from an individual property.

## PART 1 - MOTH BAY ORES

### Ore

The Moth Bay zinc-copper property is on Revillagigedo Island 15 miles southeast of Ketchikan, Alaska. The material tested in the laboratory was a composite prepared from channel samples taken from the various adits of the mine during the investigation. The material was composited in weighted proportion to the footage represented by each sample; thus the composite was considered to be representative of the exposed ore in the mine.

### Physical Character

Petrographic examination showed that the sulfides present in the ore include pyrite, sphalerite, and chalcopyrite, with minor amounts of galena and bornite. The gangue, classified as a mica schist, is essentially quartz, with barite, muscovite, biotite, chlorite, limonite, magnetite, and feldspar. The microscopic study indicated that grinding to minus-65-mesh would provide satisfactory liberation.

### Chemical Character

A partial analysis of a head sample prepared from the composite is shown in table 1.

TABLE 1. - Chemical analysis, Moth Bay

| Assay, percent | | | | | Oz. per ton | |
|---|---|---|---|---|---|---|
| Cu | Pb | Zn | Fe | Insol. | Au | Ag |
| 1.62 | 0.07 | 7.35 | 15.6 | 54.2 | 0.005 | 0.52 |

### Concentration

A series of concentration tests was run to determine the most effective method of treatment. Best results were obtained by grinding the ore to 95 percent minus-65-mesh and applying standard flotation methods.

The ore was pulped with laboratory tap water, and the pH was adjusted with lime. Zinc sulfate was employed as a sphalerite depressant in the copper circuit; sodium cyanide was used to inhibit pyrite flotation. No silica depressant or slime dispersant was required.

A copper concentrate was floated using sodium ethyl xanthate as the promoter. The copper tailing was conditioned with copper sulfate. Spahlerite was floated and cleaned once using amyl xanthate as collector.

Metallurgical results and operation data are summarized in table 2.

TABLE 2. - Flotation, Moth Bay

Metallurgical data

| Product | Weight, percent | Assay | | | | | |
|---|---|---|---|---|---|---|---|
| | | Percent | | | | Oz. per ton | |
| | | Cu | Zn | Fe | Insol. | Au | Ag |
| Cu concentrate. | 6.34 | 20.8 | 2.95 | 29.2 | 14.7 | 0.030 | 3.95 |
| Zn cleaner concentrate... | 11.88 | 1.80 | 52.0 | 10.6 | 2.9 | .005 | .44 |
| Zn cleaner tail | 1.54 | 1.40 | 15.0 | 22.0 | 28.4 | .020 | 1.16 |
| Rougher tail .. | 80.24 | .15 | .75 | 13.0 | 66.3 | Tr.1/ | .12 |
| Calculated head | 100.00 | 1.65 | 7.2 | 13.9 | 54.9 | .005 | .42 |
| Product | Weight, percent | Distribution, percent | | | | | |
| | | Cu | Zn | Fe | Insol. | Au | Ag |
| Cu concentrate. | 6.34 | 78.7 | 2.6 | 13.4 | 1.7 | 40.0 | 60.1 |
| Zn cleaner concentrate... | 11.88 | 12.8 | 85.8 | 9.1 | .6 | 12.0 | 12.5 |
| Zn cleaner tail | 1.54 | 1.3 | 3.2 | 2.5 | .8 | 8.0 | 4.3 |
| Rougher tail .. | 80.24 | 7.2 | 8.4 | 75.0 | 96.9 | 40.0 | 23.1 |
| Calculated head | 100.00 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Operation data

Grind: 95 percent minus-65-mesh

| Circuit | pH | CaO | NaCN | $ZnSO_4$ | $CuSO_4$ | Z-42/ | Z-53/ | Pine oil |
|---|---|---|---|---|---|---|---|---|
| Grind .... | 9.8 | 8.0 | 0.20 | 1.5 | - | - | - | - |
| Copper ... | 9.8 | - | - | - | - | 0.1 | - | 0.08 |
| Condition. | - | 2.0 | .05 | - | 1.5 | - | 0.10 | - |
| Zn rougher | 10.9 | - | - | - | - | - | - | - |
| Zn cleaner | 11.4 | 2.0 | .05 | - | - | - | .05 | - |
| Total... | | 12.0 | .30 | 1.5 | 1.5 | .1 | .15 | .08 |

1/ Calculated as 0.0025 ounce Au per ton.
2/ Sodium ethyl xanthate.
3/ Potassium amyl xanthate.

By selective flotation, 78.7 percent of the copper, 40.0 percent of the gold, and 60.1 percent of the silver were recovered in a copper rougher concentrate that assayed 20.8 percent Cu, 2.95 percent Zn, 0.03 ounce Au, and 3.95 ounces Ag per ton. The zinc cleaner concentrate contained 85.8 percent of the total zinc; it assayed 52.0 percent Zn and 1.8 percent Cu.

## PART 2 - THREEMAN MINE

### Ore

During the investigation of the property by engineers of the Bureau of Mines, a series of fourteen channel samples were obtained from the Threeman mine, Port Fidalgo area, Prince William Sound, Alaska. For laboratory study, the channel samples were composited to yield a sample comparable in grade and character to the known ore body of the Threeman deposit and of the similar ore deposits of the Port Fidalgo area.

### Physical Character

Petrographic study showed that the Threeman ore, as represented by the composite sample tested, essentially contains chlorite, altered ferromagnesian minerals, altered feldspar, quartz, some chalcopyrite, and small amounts of calcite, pyrite, pyrrhotite, and epidote; also present is a very small amount of sphalerite.

Optimum liberation occurs in the minus-65-, plus-100-mesh fraction, but the bulk of the chalcopyrite is liberated in the minus-48-, plus-65-mesh fraction.

Previous petrographic studies of ores from Prince William Sound indicate that a portion of the mineral identified as chalcocite may be chalmersite.

### Chemical Character

The partial chemical analysis shown in table 3 indicates the chemical character of the sample of Threeman ore tested in the laboratory.

TABLE 3. - Chemical analysis, Threeman

| Assay, percent | | | | | | Oz. per ton | |
|---|---|---|---|---|---|---|---|
| Cu | Fe | Insol. | Zn | Ni | Co | Au | Ag |
| 1.65 | 15.1 | 49.3 | 1/0.05 | 0.01 | 0.02 | Tr. | 0.36 |

1/ Less than.

### Concentration

A series of flotation tests was run to determine the best grind and reagent combination for treatment of the ore. Although good recoveries of copper were obtained by rougher flotation of ore ground to minus-48- or 65-mesh, difficulty was experienced in cleaning the rougher concentrate. Partial oxidation of the ore samples, as received, reduced the floatability of the copper minerals and activated the iron sulfides; this made separation of copper and iron minerals more difficult than if the sulfides had not been partly oxidized.

Several tests were made in which the rougher concentrate was reground before cleaning. The metallurgical results and operation data shown in table 4 are typical of this group of tests.

Regrinding of the flotation rougher concentrate for 12 minutes and treating the reground product in 3 cleaning stages yielded a concentrate that assayed 28.4 percent Cu, 35.3 percent Fe, and 1.9 percent acid-insoluble matter; this concentrate contained 81 percent of the total copper in the ore. More than 13 percent of the total copper reported in the cleaner tailing; if this product were retreated, recovery of copper probably would be increased slightly.

TABLE 4. - Flotation, Threeman

Metallurgical data

| Product | Weight, percent | Assay, percent | | | | Distribution, percent |
|---|---|---|---|---|---|---|
| | | Cu | Co | Fe | Insol. | Cu |
| Concentrate ..... | 4.28 | 28.4 | 0.01 | 35.3 | 1.9 | 81.1 |
| Combined cleaner tails .. | 8.08 | 2.5 | .06 | 27.5 | 32.4 | 13.6 |
| Rougher tail ..... | 87.64 | .09 | .01 | 12.6 | 51.7 | 5.2 |
| Calculated head ..... | 100.00 | 1.5 | .02 | 14.8 | 48.0 | 100.0 |

Operation data

| Circuit | Time, min. | pH | Reagents, pounds per ton | | | |
|---|---|---|---|---|---|---|
| | | | CaO | NaCN | Z-3 1/ | MIC 2/ |
| Grinding ..... | - | - | - | - | - | - |
| Conditioner ..... | 5 | 9.8 | 1.0 | 0.1 | 0.25 | 0.10 |
| Rougher ..... | 6 | 9.8 | - | - | - | - |
| Regrind ..... | 12 | - | 1.0 | - | - | - |
| Cleaner 1 ..... | 2 | 10.0 | - | - | - | .05 |
| Cleaner 2 ..... | 2 | 9.5 | - | - | - | - |
| Cleaner 3 ..... | 2 | 7.5 | - | - | - | - |
| Total ..... | | | 2.0 | .1 | .25 | .15 |

1/ Potassium ethyl xanthate.
2/ Methyl isobutyl carbinol frother.

The small amount of cobalt present in the ore, which apparently is associated with pyrrhotite, was concentrated to some extent in the cleaner tailing.

## PART 3. - GOLDEN ZONE MINE

### Ore

As part of the examination of the Golden Zone property near Colorado Station, Alaska, members of the Bureau of Mines staff procured a number of trench and channel samples. Several of the samples were composited to represent ore in the upper level ore zone of the deposit; similarly, other samples were blended to make a sample representative of lower level ore. The two composite samples were submitted to the laboratory for beneficiation tests.

### Physical Character

Petrographic study of the material showed that the upper level sample consists of arsenopyrite, chalcopyrite, and relatively small amounts of sphalerite, cerussite, pyrite, a trace of smithsonite associated with sericite, quartz, a magnesian-bearing calcite, and small amounts of limonite and chlorite.

The lower level sample is similar except for the lack of sphalerite and lesser amounts of chalcopyrite. A portion of the chalcopyrite in this sample is tarnished with an iridescent coating.

Microscopic examination showed that most of the sulfides in both samples are unlocked in the minus-65-, plus-100-mesh fraction; grinding through 100-mesh, however, is required to provide optimum liberation.

## Chemical Character

Partial chemical analyses of representative portions of the two composite samples are shown in table 5.

TABLE 5. - Chemical analysis, Golden Zone

| Sample | Assay, percent | | | | | | | Oz. per ton | |
|---|---|---|---|---|---|---|---|---|---|
| | Cu | Pb | Zn | Fe | As | Sb | Insol. | Au | Ag |
| Upper ..... | 0.97 | 1/0.05 | 0.32 | 10.4 | 4.1 | 1/0.1 | 62.6 | 0.18 | 3.40 |
| Lower ..... | .24 | 1/ .05 | 1/.05 | 9.5 | 14.9 | 1/ .1 | 64.0 | .23 | 1.25 |

1/ Less than.

## Concentration

A series of preliminary tests was run to investigate the amenability of the Golden Zone ore to concentration by gravity and flotation methods. It was determined that the most suitable treatment involved grinding essentially to minus-100-mesh, followed by selective flotation of copper and arsenic minerals. In each test the copper rougher concentrate was cleaned once; the cleaner tailing was returned to the circuit before flotation of the arsenopyrite. The cleaner tailing from the arsenopyrite flotation was added to the rougher tailing for assay. Operation data and results are shown in tables 6 and 7.

TABLE 6. - Flotation, Golden Zone, upper level

Metallurgical data

| Product | Weight, percent | Assay | | | | | | Distribution, percent | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Percent | | | | Oz. per ton | | | | |
| | | Cu | As | Pb | Zn | Au | Ag | Cu | Au | Ag |
| Cu concentrate.. | 3.03 | 26.6 | 1.5 | 1.4 | 2.8 | 3.12 | 59.9 | 82.3 | 57.9 | 60.9 |
| As concentrate.. | 12.62 | .85 | 22.6 | - | - | .48 | 5.9 | 10.9 | 37.2 | 25.0 |
| Tailing ..... | 84.35 | .08 | - | - | - | .01 | .5 | 6.8 | 4.9 | 14.1 |
| Calculated head. | 100.00 | .98 | | | | .16 | 3.0 | 100.0 | 100.0 | 100.0 |

Operation data

Grind: 97 percent minus-100-mesh

| Circuit | Time, min. | pH | Reagents, pounds per ton | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | $Na_2CO_3$ | NaCN | M-27 1/ | P.O. 2/ | $H_2SO_4$ | Z-6 3/ |
| Conditioner ..... | 3 | 9.6 | 10.0 | 0.05 | 0.03 | 0.04 | - | - |
| Cu rougher ..... | 3 | - | - | - | - | - | - | - |
| Cu cleaner ..... | 2 | 9.5 | - | - | - | .04 | - | - |
| Conditioner ..... | 2 | 6.7 | - | - | - | .08 | 3.0 | 0.2 |
| As rougher ..... | 5 | - | - | - | - | - | - | .1 |
| As cleaner ..... | 2 | 7.0 | - | - | - | - | 1.0 | - |
| Total ..... | | | 10.0 | .05 | .03 | .16 | 4.0 | .3 |

1/ Minerec 27.
2/ Pine oil.
3/ Pentasol xanthate.

TABLE 7. - Flotation, Golden Zone, lower level

Metallurgical data

| Product | Weight, percent | Assay | | | | | | Distribution, percent | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Percent | | | | Oz. per ton | | | | |
| | | Cu | As | Pb | Zn | Au | Ag | Cu | Au | Ag |
| Cu concentrate.. | 1.28 | 13.4 | 5.7 | 0.75 | 0.55 | 11.4 | 53.2 | 66.8 | 57.3 | 49.7 |
| As concentrate.. | 19.52 | .31 | 33.4 | - | - | .50 | 1.9 | 23.8 | 39.5 | 27.1 |
| Tailing ..... | 79.20 | .03 | - | - | - | .01 | .4 | 9.4 | 3.2 | 23.2 |
| Calculated head. | 100.00 | .26 | | | | .25 | 1.35 | 100.0 | 100.0 | 100.0 |

Operation data

Grind: 97 percent minus-100-mesh

| Circuit | Time, min. | pH | Reagents, pounds per ton | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | $Na_2CO_3$ | NaCN | M-27[1] | P.O.[2] | $H_2SO_4$ | Z-6[3] |
| Conditioner ..... | 3 | 9.7 | 10.0 | 0.05 | 0.03 | 0.04 | - | - |
| Cu rougher ..... | 3 | - | - | - | - | - | - | - |
| Cu cleaner ..... | 2 | 9.3 | - | - | - | .04 | - | - |
| Conditioner ..... | 2 | 6.7 | - | - | - | .08 | 4.0 | 0.2 |
| As rougher ..... | 5 | - | - | - | - | - | - | .1 |
| As cleaner ..... | 2 | 6.2 | - | - | - | - | 1.0 | - |
| Total ..... | | | 10.0 | .05 | .03 | .16 | 5.0 | .3 |

1/ Minerec 27.
2/ Pine oil.
3/ Pentasol xanthate.

Selective flotation of upper level ore (0.97 percent Cu) yielded a copper concentrate assaying 26.6 percent Cu, 1.5 percent As, 3.12 ounces Au, and 59.9 ounces Ag per ton; the product contained 82.3 percent of the copper, 57.9 percent of the gold, and 60.9 percent of the silver. Over 10 percent of the copper, 37 percent of the gold, and 25 percent of the silver reported in an arsenopyrite concentrate that assayed 0.85 percent Cu, 22.6 percent As, 0.48 ounce Au, and 5.9 ounces Ag per ton.

A similar test on upper level ore yielded a lower grade copper concentrate containing 87 percent of the copper, 71 percent of the gold, and 65 percent of the silver. This product assayed 16.5 percent Cu, 2.24 ounces Au, and 40.75 ounces Ag per ton but also contained approximately 5 percent As, which probably would be objectionable.

The high-arsenic lower level ore (0.24 percent Cu) was less amenable to treatment. Best results showed copper, gold, and silver recoveries of 66.8, 57.3, and 49.7 percent, respectively, in a copper concentrate that assayed 13.4 percent Cu, 5.7 percent As, 11.4 ounces Au, and 53.2 ounces Ag per ton. The arsenopyrite concentrate contained 23.8 percent of the copper, 39.5 percent of the gold, and 27.1 percent of the silver; the product assayed 0.31 percent Cu, 33.4 percent As, 0.50 ounce Au, and 1.9 ounces Ag per ton.

Roasting and cyanidation tests on arsenopyrite concentrates produced by selective flotation of the two samples gave unsatisfactory results.

## PART 4 - MACLAREN RIVER

### Ore

Representatives of the DMEA field team submitted a sample of ore for evaluation and testing from the Kathleen-Margaret prospect of the Alaska Copper Mines, Inc., Maclaren River, near Paxton, Alaska.

### Physical Character

The material submitted to the laboratory consists chiefly of quartz and basaltic lava with a small amount of chalcopyrite and minor amounts of bornite, chalcocite, and pyrite. The copper minerals are liberated by grinding to minus-65-mesh.

### Chemical Character

Table 8 shows a partial chemical analysis of a representative sample of the ore:

TABLE 8. - Chemical analysis, Maclaren

| Assay, percent | | | | | Oz. per ton | |
|---|---|---|---|---|---|---|
| Cu | Fe | S | Insol. | Ni | Au | Ag |
| 1.2 | 5.8 | 1.0 | 71.2 | 1/0.02 | Tr. | 0.04 |

1/ Less than.

### Concentration

Laboratory testing indicated that, after grinding to minus-65-mesh, the Maclaren sample was amenable to standard flotation procedures for the production of copper concentrates of marketable grade. Typical results are shown in table 9.

TABLE 9. - Flotation, Maclaren

Metallurgical data

| Product | Weight, percent | Assay, percent | | | Distribution, percent |
|---|---|---|---|---|---|
| | | Cu | Fe | S | Cu |
| Concentrate ..... | 2.85 | 36.7 | 20.8 | 23.6 | 95.9 |
| Cleaner tail ..... | 1.23 | 1.3 | 10.0 | .89 | 1.5 |
| Rougher tail ..... | 95.92 | .03 | 5.2 | .06 | 2.6 |
| Calculated head .... | 100.00 | 1.1 | 5.7 | .74 | 100.0 |

Operation data

Grind: Stage-ground to minus-65-mesh

| Circuit | Time, min. | pH | Reagents, pounds per ton | | |
|---|---|---|---|---|---|
| | | | $Na_2CO_3$ | Z-6 1/ | Frother 2/ |
| Condition ..... | 2 | - | 2.0 | 0.1 | 0.04 |
| Rougher ..... | 3 | 9.5 | - | - | - |
| Cleaner ..... | 2 | 9.0 | - | - | .04 |
| Total ..... | | | 2.0 | .1 | .08 |

1/ Pentasol xanthate. 2/ Dowfroth 250.

By flotation, 95.9 percent of the total copper in the Maclaren sample was recovered in a concentrate that assayed 36.7 percent Cu.

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