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REPORT OF THE METALLURGICAL TEST

OF THE VANGORDA ORE

FOR KERR ADDISON

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REPORT ON BENEFICIATION OF THE VANGORDA ORE

This report is based on the fundamental investigations and the metallurgical test results obtained at the Kosaka laboratory of Dow. The tests were mainly conducted on the Vangorda Ore, of which the ore samples are no. 1, 2, 3, 4, 5, 6 and 7.

1. Basic Study

1.1. Summary of Mineralogical Investigation

Information obtained in mineralogical investigations are summarized as follows:

The determination of the component minerals was done by microscoping, x-raying and chemical analysis respectively. The lead minerals are mostly galena but 0.29 per cent of lead is assayed as $PbSO_4$. The copper is chalcopyrite and the zinc is sphalerite. The ~~iron~~^{gangue} materials consist of barite, talc, quartz and minor amount of silicate minerals.

The component sulfide minerals are finely interlocked with each other and small amounts of the sulfide minerals existing in gangue minerals are approximately 50 per cent of the ore.

The result of the complete analysis of Vangorda Ore is shown in Table 1. The Leaching test result is shown in Table 2.

Table 1 Result of the Complete Analysis of the Vangorda Ore.

| Cu | Pb | Zn | Fe | S | $PbSO_4$ | SiO_2 | $BaSO_4$ | Al_2O_3 | MgO | Mn | CaO |
|---------------|------|------|-------|---|----------|---------|----------|-----------|------|------|------|
| 0.20 | 2.87 | 5.10 | 23.53 | | 0.29 | 12.84 | 20.50 | 1.64 | 1.48 | 0.66 | 1.34 |
| Assy gram/ton | | | | | | | | | | | |
| Au | Ag | | | | | | | | | | |
| 0.7 | 55 | | | | | | | | | | |

Table 2 Results of the leaching test.

| | ASSAY (ppm) | | | | | | |
|-----------------------------------|-------------|-------|--------|-------|-----------------|-------|--------------------------------|
| | Cu | Zn | Fe | CaO | SO ₄ | Mn | Al ₂ O ₃ |
| Distilled water | 0.64 | 0.52 | 1.38 | 74.94 | - | - | - |
| H ₂ SO ₄ 5% | 0.78 | 429.0 | 7280.0 | 907.0 | 42650.0 | 863.0 | 226.0 |

(Condition of the leaching test; 20% solids, 30 min. leaching)

Table 3 Result of the sizeing analysis.

| SIZE (micron) | Weight (%) | ASSAY (%) | | | | DISTRIBUTION (%) | | | | |
|---------------|------------|-----------|------|------|-------|------------------|-------|-------|-------|--|
| | | Cu | Pb | Zn | Fe | Cu DI | Pb | Zn | Fe | |
| +104 | 0.3 | 0.10 | 0.20 | 1.06 | 18.79 | 0.1 | 0.1 | 0.1 | 0.2 | |
| -104 +75 | 1.5 | 0.10 | 0.40 | 1.32 | 14.87 | 0.5 | 0.2 | 0.5 | 0.9 | |
| -75 +54 | 7.5 | 0.13 | 0.79 | 2.11 | 21.79 | 3.0 | 2.6 | 3.9 | 6.5 | |
| -54 +37 | 13.3 | 0.25 | 0.79 | 2.90 | 23.23 | 10.3 | 4.2 | 9.6 | 12.3 | |
| -37 +29.9 | 3.8 | 0.19 | 2.27 | 2.11 | 39.65 | 2.2 | 3.5 | 2.0 | 6.0 | |
| -29.9 +22.8 | 11.0 | 0.27 | 2.67 | 3.43 | 34.96 | 9.2 | 11.9 | 9.4 | 15.3 | |
| -22.8 +16.3 | 20.0 | 0.29 | 2.87 | 4.22 | 27.05 | 18.0 | 23.3 | 21.0 | 21.5 | |
| -16.3 +11.4 | 15.7 | 0.36 | 2.77 | 5.44 | 23.13 | 17.5 | 17.7 | 21.7 | 14.4 | |
| -11.4 + 9.0 | 7.9 | 0.40 | 3.06 | 4.75 | 22.10 | 9.8 | 9.8 | 9.3 | 6.9 | |
| -9.0 | 19.0 | 0.50 | 3.46 | 4.75 | 21.27 | 29.4 | 26.7 | 22.5 | 16.0 | |
| HEAD CALC. | 100.0 | 0.32 | 2.46 | 4.02 | 25.19 | 100.0 | 100.0 | 100.0 | 100.0 | |

2. Floatation Test

In this chapter, the test results of the preliminary floatation test and the selective floatation test concerning three concentrates are described.

2.1. Summary of the Preliminary Floatation Test.

As a preliminary examination, some floatability tests were run for the purpose of familiarizing our investigators with the Vangorda Ore. We obtained some suggestions contributing to the process research through the testing.

0.039 mm

Each 500 gram sample was ground to 39 microns minus 80 per cent for the floatability tests. The sample, after being transferred to the floatation machine bowl, was diluted to 25 per cent solids. The conditioning was done in the bowl with the air valve closed, then the sample was floated.

20 mesh

$$0.039 \text{ mm} = \frac{1}{25} \times 25 \text{ mm}$$

$$x = \frac{250}{.075} = \frac{25000}{75} = 320 \text{ mesh minus } 5\%$$

Recast - 1/200

The results of the floatability test are tabulated in Fig. 1, 2, 3, 4 and 5. Certain symbols and abbreviations are used in the figures.

A key to these is shown below;

Cu — \triangle —: copper distribution and grade
Pb — \times —: lead distribution and grade
Zn — \triangle —: zinc distribution and grade
Fe — \circ —: iron distribution and grade

The test results of no. 3, 10, 11 and 17 indicate that the selectivity of Cu Pb - Zn Fe is excellent. The test result of no. 2 indicates that the lead recovery was the richest, while the sample was being floated without any depressant.

Through the preliminary tests, it is made clear that using an excess of collectors and depressants is not effective for the Vangorda Ore.

(see Fig. 1 - 5)

2.2. Summary of the Selective Floatation Test

The flow sheet of the selective floatation test which is shown in Fig 6, was arranged based on the results of the preliminary floatation tests and considering cost performance of floatation methods in actual operation and restrictions of environmental control in future.

The two kilo-gram ore samples were used and ground to 39 microns minus 80 percent for Cu Pb-semi bulk-rougher-floatation tests. The result of the sizing analysis is shown in table 3.

2.2.1 Copper Lead Semi-Bulk Floatation -

In the rougher flotation, the sample was diluted to 39 percent solids, then was floated by using sodium amyl xanthate and Dow #250 frother without any depressant.

The rougher concentrate was reground, conditioned by using Na_2S for collector desorption and small amount of NaCN for deactivator of zinc and iron sulfides respectively, and then floated by using CaCO_3 and sulfurous acid as depressants.

The semi-bulk cleaner concentrate was fed in to the special conditioning section, which provided for copper-lead selective floatation to remove copper and iron sulfide from lead. The pulp was controlled at pH 50 by using sulfurous acid and $\text{Ca}(\text{OH})_2$, and kept at 70°C by heating. Copper, iron sulfides and sphalerite were floated by using sodium amyl xanthate and Dow #250 frother. The froths were reground and retreated to recover copper concentrate, and removed zinc concentrate. Galena remained in the tailing.

2.2.3 Zinc Floatation

The copper lead semi-bulk rougher tailing and the cleaner tailings were fed into the zinc floatation section. At the conditioning of zinc rougher floatation, the pulp was controlled at pH 90 by using $\text{Ca}(\text{OH})_2$ and CuSO_4 to activate sphalerite. The zinc rougher concentrate was reground adding $\text{Ca}(\text{OH})_2$, and floated at pH 11.0 - 11.5. The metallurgical result is shown in Table 4. This flow sheet is shown in Fig 6 as well.

3. Cycle Test of Selective Floatation

The cycle test was carried out, and the flowsheet is shown in Fig. 7. Tailings of each cleaning circuits were mixed and treated with the refered rougher section of next stage as shown in Fig. 7. Three concentrates were produced, while copper recovery was 50 per cent, lead was 78.3 per cent and zinc was 86.6 per cent. The middlings of the first

and second stages will be recycled to each next stage. The water used for the test was fresh water for the first stage, but the recycled water was used for the second and the third. (See Table 5, Fig. 7)

4. Comment

a) Mineralogical investigation, preliminary floatation test selective floatation and cycle tests were done. The interesting flowsheet for the Vangorda Ore wad introduced according to the application of the special process which was developed by Dowa Mining co. In the actual operation, also, the better metallurgical result can be expected by applying our method.

b) Although data of reagent consumption of selective floatation in this test concerning above 2.2.3 and 3. are also available, These are not indicated in this report in the light of secrecy of know-how of our process. We, however, are prepared to discuss with you for the disclosure of such information according to the further progress of negotiation with you on this matter.

c) We can continue further tests of the Vangorda and Swim Lake Ore, if requested.

50% 325 mesh

Table 5 Result of cycle test

| | Weight | Assay (%) | | | | Distribution (%) | | | |
|----------------|--------|--------------|--------------|--------------|-------|------------------|-------------|-------------|-------|
| | % | Cu | Pb | Zn | Fe | Cu | Pb | Zn | Fe |
| Pb concentrate | 3.91 | 0.14 | <u>61.72</u> | 5.07 | 5.70 | 2.4 | <u>78.3</u> | 4.5 | 0.9 |
| Zn concentrate | 6.92 | 0.26 | 2.42 | <u>55.30</u> | 7.60 | 8.6 | 5.4 | <u>86.6</u> | 2.2 |
| Cu concentrate | 0.58 | <u>18.13</u> | 6.97 | 5.00 | 30.16 | 50.0 | 1.3 | 0.6 | 0.7 |
| Talc ro. conc. | 0.33 | 0.57 | 4.45 | 3.92 | 11.14 | 1.0 | 0.5 | 0.3 | 0.2 |
| Middling (1) | 0.55 | 3.80 | 6.23 | 3.70 | 30.67 | 10.0 | 1.1 | 0.5 | 0.7 |
| Middling (2) | 9.21 | 0.30 | 2.86 | 2.42 | 34.35 | 13.3 | 8.5 | 5.0 | 13.1 |
| Zn ro. tail | 78.50 | 0.04 | 0.19 | 0.14 | 25.23 | 14.7 | 4.8 | 2.5 | 82.2 |
| Head | 100.00 | 0.21 | 3.08 | 4.42 | 24.10 | 100.0 | 100.0 | 100.0 | 100.0 |