Feasibility assessment of dry pre-concentration for gold-bearing ore

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Abstract. The present research is intended to estimate efficiency of dry preconcentration of ores originated from Gurbey deposit, the Irkutsk Region, as a case study and to develop a rational flowsheet to process ores bearing free gold. The dry preconcentration of Gurbey gold-bearing ores is studied at semi-industrial equipment including DKD-300 combined impact crusher, CMBU-800 centrifugal mill, and POS-2000 pneumatic separator designed at Chersky Mining Institute of the North, SB RAS. The test specimen is subjected to two crushing cycles and four grinding cycles followed by the pneumatic separation cycle. The circulating load consisted of +12 mm fraction after DKD-300, the return mill feed is the sized product of +3 mm as well as products of classification of -3+1 mm POS-200 concentrate. The follow-on recleaning treatment of the preconcentrated products at tables, Moseley mineral analyser, magnetic separator, heavy-medium separator (tribromomethane CHBr₃) yielded 23.93 g of free gold. Thereto, it is established that the complete release and recovery of gold up to 100 µm in size can be gained at POS-2000 pneumatic separator at 60% gold recovery into the primary concentrate. The present research data were used as the basis to develop the principal dry preconcentration scheme to process Gurbey ores, bearing “free” gold.

1. Introduction
The feasibility of the dry ore preconcentration is assessed on the ore originated from Gurbey deposit, the Irkutsk Region. The research data are intended to work out a rational processing flowsheet for ores bearing free gold.

The selection of Gurbey ore bearing a wide granulometric range of free gold in size and dissemination degree is considered as a principal one in terms of investigation into depth of release and recovery of gold.

The study ore is ranked as gold-quartz-sulfide low–sulfide ore type and mainly consists of lithophilous components (86.0%) with dominating silicon oxide (59.08%). The principal ore-forming components are iron and sulfur. The main rock-forming minerals are quartz (22.8%), chlorite (21.7%) and feldspars (20.7 %). Sulfide components of the study ore are pyrrhotite (2.3%) and pyrite (1.8%). Gold is generally rather high karat gold being highly pure within 938–964 units. Dominating portion of gold (79.6 %) is of +0.071 mm in size. A portion of small and finely dispersed gold grains (-0.071 mm) amounts to 20.4% [1].

Investigation into dry preconcentration of Gurbey gold-bearing ore of 1123.8 kg in the initial weight, is carried out at semi-industrial equipment: DKD-300 combined impact crusher [2], CMVU-800 centrifugal mill [3], and POS-2000 pneumatic separator [4], developed at Chersky Mining Institute of the North, SB RAS (Figure 1).
2. Study procedure

The initial ore specimen contained about 20% of ore fines of -1 mm in size. In view of this feature the initial ore specimen was screened into fractions of +12 mm, +3 mm, and -3 mm in size. The initial ore specimen was classified into the following fractions: +12 mm, -673.4 kg, -12 +3 mm, -197.1 kg, -3 mm, -2 53.3 kg, in total 1123.8 kg. Granulometric characteristic of the initial specimen is reported in Table 1. The study flowsheet is shown in Figure 2.

| Size fraction, mm | Yield kg | % |
|-------------------|----------|---|
| +100              | 173.51   | 15.44 |
| -100+40           | 240.72   | 21.42 |
| -40+20            | 181.61   | 16.16 |
| -20+10            | 122.61   | 10.91 |
| -10+5             | 57.20    | 5.09  |
| -5+2              | 84.62    | 7.53  |
| -2+1              | 45.06    | 4.00  |
| -1+0,0            | 218.47   | 19.44 |
| Total             | 1123.80  | 100.00 |

Fraction of +12 mm was subjected to crushing at DKD-300, fraction of -12 +3 mm is fed to CMVU-800 mill. Fraction of -3 mm was processed at POS-2000 pneumatic separator. It is important to point out that the nominal size of the pneumoseparator feed used to be -1 mm. In the study case the higher coarseness of the initial pneumoseparator feed was accepted in order to provide the maximum concentration of gold to be released within the ore mass.

The pneumoseparator concentrate was screened into two fractions: +1 and -1 mm. Fraction of -1 mm is fed to concentration tables, the table concentrate is recleaned at Moseley concentrator. The final recovery of free gold was performed by magnetic separation and heavy medium separation (tribromomethane CHBr$_3$).

The ore specimen was subjected to cyclic crushing and grinding (4 cycles). Fraction of +12 mm being a DKD-300 product is returned to the crushing circuit. All the screening products of +3 mm as well as POS-2000 product of -3+1 mm are returned to the grinding circuit. Herewith, the processing at CMVU-800 and POS-2000 is rigidly related. The sampling and preparation of samples for granulometric and assay tests for gold content (tailings) were performed individually for each operation.

At the final stage the researchers performed the balance analysis of products in terms of gold content and calculations of recovery in ore processing circuits: crushing-grinding-pneumoseparation.
Crushing was conducted according to the general flowsheet for ore specimen processing with crushing of +12 mm fraction, including the return fractions after crushing (the basis to form the circulating load in the technological crushing scheme).

Figure 2. Ore processing flowsheet.

In the course of the tests it was established that two cycles of crushing at DKD-300 are enough for the study amount of ore specimen (Table 2).

Table 2. Granulometric composition of DKD-300 products

| Fraction, mm | Yield, %  |
|--------------|-----------|
|              | Initial ore | 1st cycle | 2nd cycle |
| -0.063       | 5.98       | 2.93       | 2.25       |
| -0.1 +0.063  | 2.64       | 2.27       | 2.21       |
| -0.315+0.1   | 5.76       | 7.35       | 6.03       |
| -0.5+0.315   | 1.88       | 3.71       | 2.58       |
| -1+0.5       | 3.19       | 7.46       | 5.46       |
| -2+1         | 4.00       | 9.67       | 8.00       |
| -5+2         | 7.53       | 20.73      | 20.46      |
| -10+5        | 5.09       | 15.25      | 15.47      |
| -20+10       | 10.91      | 19.85      | 29.6       |
| -40+20       | 16.16      | 10.78      | 7.94       |
| -100+40      | 21.42      | -          | -          |
| +100         | 15.44      | -          | -          |

Crushing degree: 8.40%
The grinding tests were held at CMVU-800 centrifugal mill according to the general technological scheme to process ore specimens with crushing of -12+3 mm fraction. In the operation of CMVU-800 the crushing induces formation of finely dispersed dust-like material of -0.063 mm in size and up to 32% of total amount of the material to be crushed. Thereto there is mechanical spillage of the material under mill discharge. The total yield of the control size fraction of 0.063 mm is assessed within 35% of the initial one, viz., in this case the grinding is considered as a rough grinding stage. As for grinding efficiency, the issue of complete free-gold release is of specific importance to improve selectivity to the maximum for ores with quartz matrix.

The treatment at circuits of scavenger and recleaning tabling, Moseley concentrator, magnetic separation, heavy medium separation (tribromomethane CHBr₃) of the concentrated products yielded 23.93 g of free gold, including 9.22 g from -3mm fraction of coarse screening of the initial ore specimen, viz., 38.56% of the total gold recovery or primary free gold content in the initial ore specimen.

As gold is released in crushing and grinding circuits, the amount of recoverable free gold notably descends, thus confirming a rather selective release depending on coarseness and character of gold dissemination in ore, location of gold in texture of ore matrix. In general the release additionally gives 5.45 g of gold. However the recovery parameter is already lower and amounts to 77.56%; the yield of POS-2000 concentrate gives 45%. Tailings of POS-2000 are specified with lower grade of 19 g/t according to the reliable atomic-adsorption assay data. High gold content in tailings of tables and Moseley analyzer: 17.4 and 34.8 g/t indicates approximately identical, but low gold beneficiation ability of dry separation, and wet gravity separation processes. One of potential reasons can be fine dissemination of gold in ore. This statement is the subject for further research and technological evaluation.

![General flowsheet of the dry gold-bearing ore pre-concentration on Gurbey ore as a study case.](image-url)
Figure 3 demonstrates the new-proposed principal dry ore preconcentration flowsheet with controllable crushing and grinding processes by means of circulating streams through classifying facilities (screens).

3. Conclusions

The new-developed general scheme for dry preconcentration of an ore containing “free” virgin gold involves ore-preparation machinery: RD-MDV-900, DKD-300, centrifugal mill CMVU-800, and pneumatic separator POS-2000 with complete release and recovery of gold of up to 100 µm in size into the primary concentrate. The pneumatic separation product is -1 mm in size, contains 2068.68 g/t of gold vs the initial gold content of 34.97 g/t at 59.16% recovery.

The new proposed general dry gold ore pre-concentration scheme has the limiting factors dealing with feasibility of the complete release and recovery of gold of more than 100 µm in size. These factors serve the basis for establishing other technological parameters, namely, recovery, concentration ratio, gold content in tailings of the critical value for further processing operations.

Economic utility: the general flowsheet for dry pre-concentration at apparatus for crushing, grinding, and pneumatic separation is universal for all the ores containing free gold. Efficiency of the process depends on the granulometric characteristic of gold, pattern of mineral dissemination in an initial ore and physical and mechanical features of the ore.

References

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