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POTENTIAL ENHANCEMENT OF COMPREHENSIVE COPPER–MOLYBDENUM ORE DRESSING BY PARTIAL INVOLVEMENT OF TAILINGS

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Tailings of complex ore processing plants using bulk–selective flotation chart are composed of a number of products. Metal content of final concentration tailings is comparable with the metal content of initial ore, thus, these tailings can be a resource supply for processing plants. The article describes the approach to selecting processing circuits and using their tailings as a feed for independent process stages. At such process stages, it is possible to either produce bulk concentrates for blending with some other products of a processing plant, or to arrange self-sustained production of marketable concentrates. The implementation of the approach at a copper–molybdenum ore processing plant is instantiated. The developed flow chart allows production of quality copper, molybdenum and pyrite concentrates.

The authors also describe the approach to estimating processibility of tailings of process stages. It is shown that it is feasible to select some process stages in the flotation flow chart and use their tailings as a feed for independent processing. This approach is actualized in the final concentration cycle of dressing of Erdenet copper–molybdenum ore (Mongolia). The technology of production of quality marketable copper, molybdenum and pyrite concentrates has been developed.

Key words: *copper–molybdenum ore, flotation tailings, final concentration circuit, flotation, quality concentrate.*

The current and aged mining and processing waste are composed of overburden, subeconomic ore and tailings. These localized accumulations and their content of commercial components, often comparable with the commercial mineral content of currently produced ore, suggest considering them as standby reserves [1]. At the same time, the nature and process properties of mining waste components vary appreciably; for this reason, if a processing plant (PP) uses its customary flow charts for treating old tailings, the final product will have low handling abilities. So, from the viewpoint of the technology and considering drastic change in phase composition (first of all, sulfide and oxidized forms) of old mining waste, it is preferable to process current tailings. Actual methods of re-extraction of metals from current tailings are mostly based on mechanical classification of tailings with "trapping" of froth product enriched with nonferrous metals. Yield of the tailings change in this case within the limits of statistical error, and the obtained middlings cannot be assumed as a marketable product due to its quality. Nevertheless, inasmuch as total tailings are composed of tailings of a few process stages, including final concentration, it is possible to identify process stages tailings of which can be used as a feed for cycle-independent process stages.

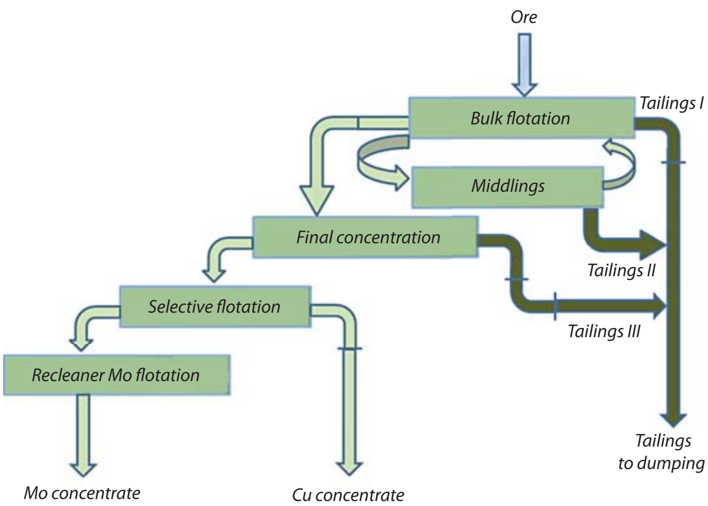

Fig. 1. General layout of copper–molybdenum ore dressing at Erdenet PP

At the present time, the Erdenet processing plant operates the two-phase Cu–Mo ore dressing flow chart [2]. The flow chart includes three sequential process stages (**Fig. 1**): bulk concentration with production of bulk Cu–Mo concentrate with the Cu content of 15–17% and Mo content of 0.4–0.5%; final concentration (copper–molybdenum flotation by the PP terminology) with production of Cu–Mo concentrate with the content of copper not less than 23.5%; molybdenum concentration with production of quality molybdenum concentrate (not less than 47% content of Mo); copper concentrate is the middlings of the rougher molybdenum flotation.

Consequently, Erdenet PP tailings are composed of three process products:

- recleaner bulk flotation tailings (tailings I);
- middling cycle tailings (tailings II);
- Cu–Mo flotation tailings (tailings III).

Structurally, the final concentration cycle is a canonical flow chart of the rougher, recleaner and scavenger flotations. The scavenger flotation froth is the bulk Cu–Mo concentrate.

The scavenger flotation middlings are tailings III. Since the feed of this process stage is a comparatively rich bulk concentrate, the final concentration tailings are the product with the copper content of 0.2–0.5% and molybdenum content of 0.1–02%. Such copper content is explained by the presence of aggregates, reagent regime or procedural violations, but the higher degree (of the order of 10) concentration of molybdenum is first and foremost conditioned by depression of pyrite in the final concentration cycle. The objective of the cycle is the Cu–Mo concentrate with the quality content of copper (23.5%). This objective is reached by the final concentration flotation in lime environment — CaO content is 400–500 mg/l in the rougher flotation and up to 700 mg/l in the scavenger flotation. Under such conditions, depression of little molybdenum is unavoidable.

That range of contents allows assuming the final concentration tailings as a feed for self-contained flotation cycle with the production of copper and molybdenum concentrates.

The aim of this research is development of the technology for production of marketable copper and molybdenum concentrates from tailings III.

Material constitution of tailings of copper–molybdenum flotation (CMF)

The test material was samples of CMF tailings with the following chemical composition, %: 0.2–0.5 Cu, 0.1–0.2 Mo, 25–35 Fe_{total}, 28–35 S_{total}, 31.9 S_{sulf}, 20–30 SiO_2, 5–8 Al_2O_3, 1.5 K_2O, 0.4–0.8 Na_2O. These tailings had also the following phase composition, % (relative): 4–6 oxidized; 40–45 secondary; 45–50 primary; 5–10 gray copper ore; 100 total. Grain-size composition of CMF are described in the **Fig. 2**.

The mineral composition of a sample is illustrated in the **Fig. 3**.

The analysis of dissociation ability of mineral particles in CMF tailings has yielded that:

- secondary copper sulfides are mainly represented by chalcosite and bornite;
- copper and molybdenum mainly occur in aggregates with nonmetals and, partly, with pyrite;
- content of free chalcopyrite grains is under 6%, free grains of secondary minerals of copper are absent; for the both minerals, aggregates with barren rock prevail in mass—56 and 60%, respectively; up to 40% of chalcopyrite occur in relatively large aggregates — from –250 to –40 µm;
- molybdenite is almost in full dissociated; its loss in tailings is connected with the high content of CaO in process stages.

As a whole, the mineral composition and the degree of dissociation of sulfides are favorable for a technology for copper and molybdenum concentrate production, and, taking into account features of mineral dissociation, it seems rational to sequence the process stages as follows (**Fig. 4**):

- separation of molybdenum, copper and pyrite in sodium sulfide environment;
- re-grinding of molybdenum cycle tailings in order to dissociate aggregates of copper minerals;
- copper flotation with three scavenger circuits;
- pyrite cycle for copper flotation tailings in order to produce pyrite concentrate.

The feature of the offered technology is fluid phase discharge before:

- selection circuit — to reduce CaO concentration;

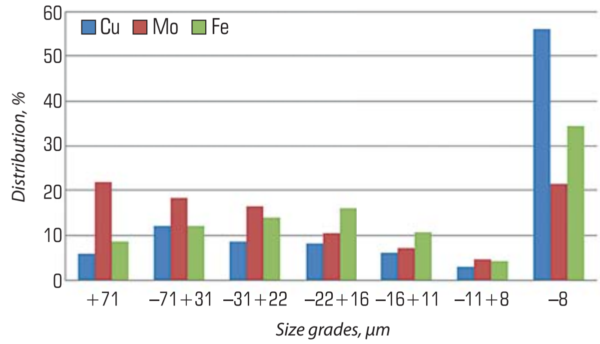

Fig. 2. Distribution of metals in size grades in CMF tailings

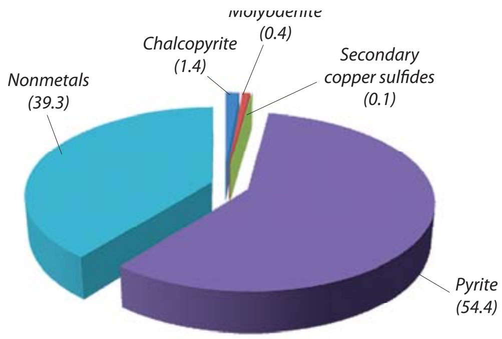

Fig. 3. Mineral composition of CMF tailings, %

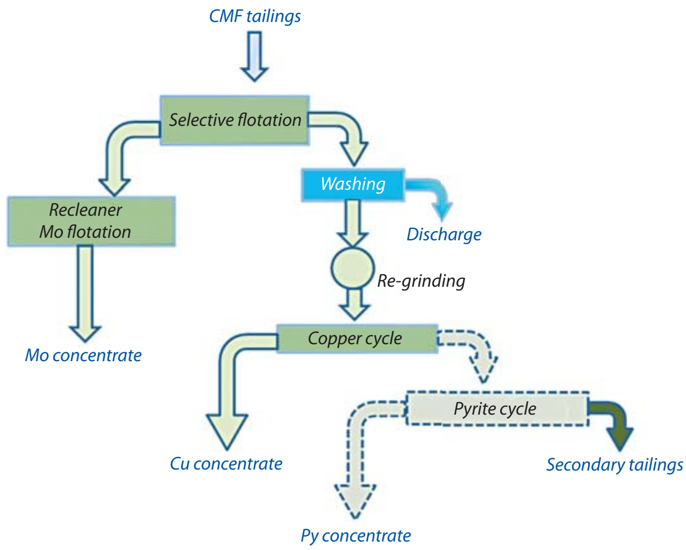

Fig. 4. General layout of CMF tailings processing

- re-grinding of the selection circuit middlings — to eliminate negative influence of residual sodium sulfide.

Since CMF tailings have generally the same mineral composition as the bulk concentrate, the current reagent regime may be kept.

In the mode of a self-contained experiment, using the CMF tailing sample with the Cu content of 0.31% and Mo content of 0.25%, we have produced:

- molybdenum concentrate (Mo content of 45.04% at the recovery of 66.25%);

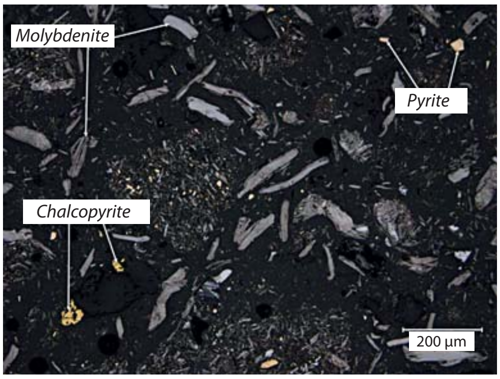

Fig. 5. Molybdenum concentrate. Reflected light, parallel nicols

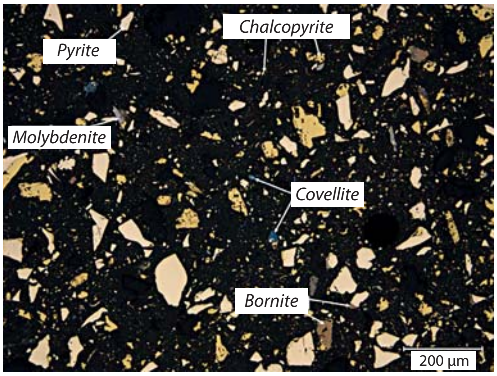

Fig. 6. Copper concentrate. Reflected light, parallel nicols

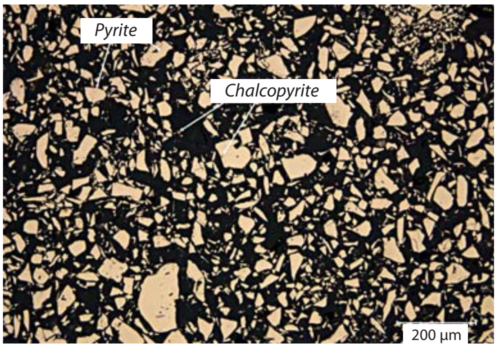

Fig. 7. Scavenger flotation pyrite concentrate I. Reflected light, parallel nicols

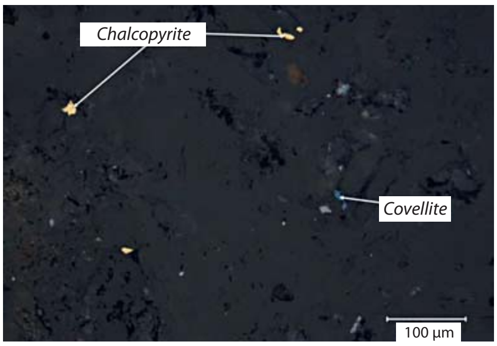

Fig. 8. Recleaner pyrite flotation tailings. Reflected light, parallel nicols

- copper concentrate (Cu content of 15.4% at the recovery of 53.24%);
- pyrite concentrate (iron content of 45.12%, sulfur content of 52.1%, iron recovery of 89.16%);
- secondary tailings (Cu content of 0.13%, Mo content of 0.09%).

Material constitution of process products of the self-contained experiment

The copper concentrate has the following phase composition, % (relative): 1.48 oxidized; 25.35 secondary; 70.28 primary; 2.89 gray copper ore; 100 total.

The comparison of data from Tables 2 and 3 yields that the incremental content of copper in the copper concentrate is achieved owing to primary copper minerals.

Molybdenum concentrate. The bulk of the concentrate is molybdenite (**Fig. 5**) present mainly in the form of free flakes and grains. There are aggregates of molybdenite with chalcopyrite, nonmetals and pyrite. Chalcopyrite occurs mainly as free grains mostly –10 µm in size and as aggregates with molybdenite.

Copper concentrate. The product contains up to 42% nonmetals. A considerable proportion of chalcopyrite occurs as crushed aggregates with nonmetals and as mixed and uncrushed aggregates with pyrite (**Fig. 6**).

The size of chalcopyrite grains in either aggregate type allowed extraction of essential chalcopyrite after re-grinding of the molybdenum cycle tailings. Small amount of molybdenite occurs both as free grains and as aggregates mostly with nonmetals. It is worthy of mentioning appreciable, comparable with chalcopyrite, content of pyrite. It is required to intensify the mode of depression of the mineral components since VK 901 collector, which is used in this cycle, is not highly selective relative to pyrite, first of all.

Pyrite concentrate contains 98% pyrite (**Fig. 7**). Copper sulfides are almost totally in aggregates with pyrite and nonmetals. Copper is distributed nearly equally between chalcopyrite and secondary copper sulfides (chalcosite, bornite and covelline). Appreciable amount of very fine grains of copper sulfides is observed in pyrite. Sphalerite, galena and molybdenite are present as rare grains.

Secondary tailing. Out of commercial minerals, the most apparent is chalcopyrite present as unlocked and locked aggregates with nonmetals (**Fig. 8**). Secondary copper sulfides are represented by covelline and bornite, they are present in much lesser amount, in aggregates with nonmetals as well. Appreciable proportion of grains of secondary copper sulfides and chalcopyrite is observed in the size grade –10 µm.

Thus, entering a portion of PP tailings, in particular, final concentration tailings, which, as a rule have comparatively high content of commercial components, in the self-contained process circuits, using relatively simple and trialed flow charts allows additional production of marketable commodities with the simultaneous reduction of the tailings storage costs.

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