MINERAL DRESSING

Kinetics of Calcium Minerals Flotation from Scheelite-Carbonate Ores

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Received May 21, 2012

Abstract—The laboratory and commercial tests of ore specimens with different content of tungstic oxide and calcite have been conducted, and basic patterns of flotation have been established. Based on the results of analytical and practical studies, the actual processing plant’s operating practice and processing flow sheet have been upgraded.

Key words: Scheelite-carbonate ore, calcium minerals, chemical feed flow sheets, flotation properties, floatability, rate of extraction.

The Primorski Krai provides approximately 55% of the total tungsten production, though the proved tungsten ore reserves in the Far East Region amount to merely ~23% of the tungsten ore reserves of Russian Federation. The Primorski Krai is ranked as one of the promising regions in Russia, where the prospected tungsten ore deposits are characterized with a variety of mineral formations and morphogenetic types: Zabytoe, Vostok-2, Lermontovskoe, etc. Currently, under exploitation are large skarn scheelite-sulfide deposits Vostok-2 and Lermontovskoe [1].

The depletion of high-grade ore reserves fosters the involvement of poor, rebellious ores and dumped waste materials into the large-scale processing at ore preparation plants. The long-term plans imply the exploitation of Skrytnoe new tungsten ore deposit which tungsten trioxide reserves are comparable to the local large skarn scheelite deposits with rather poor tungsten trioxide content within 0.2–0.4% [2, 3].

Calcite and apatite, exhibiting flotation properties close to those of scheelite, are the main minerals hampering the production of saleable scheelite concentrates from local ores. Thus, in working solution with sodium oleate concentration of 0.99⋅10\textsuperscript{-3} mol/l, the contact angle is 65° for scheelite, 64° for apatite and 65° for calcite. The density of calcium ions per unit elementary mineral surface is 0.033 for scheelite, 0.022+0.034 for apatite (two calcium cation types are specific for apatite surface), 0.05 for calcite [4, 5]. It is the common-to-them cation Ca\textsuperscript{2+}, where anions of a collecting agent are usually sorbed at. The sorption magnitude is of a constitutive importance for a mineral recovery into a concentrate. Moreover, scheelite and apatite have close dimensions of PO\textsubscript{4}\textsuperscript{3–} and WO\textsubscript{4}\textsuperscript{2–} anions and the mineral surface solubility. The solubility is 4.26⋅10\textsuperscript{-7} mol/l for apatite, 8.81⋅10\textsuperscript{-7} mol/l for scheelite at 25°C, and 1.54⋅10\textsuperscript{-7} mol/l for apatite, 2.19⋅10\textsuperscript{-6} mol/l for scheelite, 4.32⋅10\textsuperscript{-5} mol/l for calcite at 90°C [6, 7].

For pure mineral fractions recovered from Vostok-2 ore and 1.6⋅10\textsuperscript{-4} mol/l oleate ion concentration, the collector quantity, fixed at mineral surface, amounted to 9.4⋅10\textsuperscript{-10} mol/cm\textsuperscript{2} for scheelite, 7.79⋅10\textsuperscript{-10} mol/cm\textsuperscript{2} for apatite, and 7.88⋅10\textsuperscript{-10} mol/cm\textsuperscript{2} for calcite at the respective 95, 85, 80% recovery values.
As known, at high collector concentrations, typical of the full-scale production conditions, the difference in the collector adsorption can be enhanced by adding a liquid glass into a depressor solution. Figures 1 and 2 describe sorption of Vostok-2 minerals. Oleate ion sorption from solutions containing $\text{HSiO}_3^-$, $\text{OH}^-$, $\text{HCO}_3^-$, $\text{H}_2\text{SiO}_3$ at pH 9.3–9.8, and $2.2 \times 10^{-4}$ mol/l of liquid glass and $3.2 \times 10^{-4}$ mol/l sodium oleate, reduces 2.1 times for calcite, 1.1 times for apatite and does not practically change at the scheelite surface. In Fig. 3 the kinetics of the laboratory calcium mineral flotation from Vostok-2 poor ores is presented at different liquid glass/sodium oleate ratios: 350:250 g/t, 1000:170 g/t, the primary ore grade being 0.54% $\text{WO}_3$, 0.32% P, and 5.3% $\text{CaCO}_3$.

**Fig. 1.** Sodium oleate sorption at calcium mineral surface at variable liquid glass concentration: 1 — scheelite; 2 — apatite; 3 — calcite.

**Fig. 2.** Dependence between calcium mineral recovery and quantity of oleate ions sorbed at the mineral surface: 1 — scheelite; 2 — apatite; 3 — calcite.

**Fig. 3.** Kinetics of calcium mineral flotation at different liquid glass/sodium oleate ratios: (a) 350:250 g/t; (b) 1000:170 g/t; ■ — scheelite; □ — calcite; □ — apatite.