NEWT Approaches to Phosphate Ore Beneficiation Coupling Chemistry and Hydrodynamic of Flotation Process

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Igneous deposits represent the major phosphate ore reserves in South Africa, Brazil and Russia. The Kola province in Russia, where phosphorus is recovered, consists of carbonatites, alkaline silicate and ultramafic rocks. The Kovdor baddeleyite-apatite-magnetite deposit is one of the most studied and exploited deposits in carbonatite-bearing complexes of the Kola province.

A large proportion of various associated silicate gangue present in the phosphate igneous ores in addition to the manifested diversity of phosphate minerals, provides challenges to the flotation processes, which is also often complicated by the presence of the calcareous (calcite, dolomite) and naturally-floatable clays minerals. This work presents new reagent blends and flow sheets tested on different ore and tailings samples with various mineral composition, P2O5 grades and size distribution.

The experimental researches were performed at laboratory and pilot scale on the three low grade and low contrast ore samples from Kovdor deposit (The Kola Peninsula, North Russia) with P2O5 content of 3.9-13.7%. In addition, a sample of fine fraction of old tailings (D90 below 40 µm, 9% of P2O5, 14.4% CO2, CaO/P2O5=2.9) was also tested.

A detailed mineralogical study using advanced XRD, electron microscopy and spectroscopy (IR and Raman) techniques revealed that the phosphate minerals in samples were presented by fluorapatite with francolite and crandallite of weathered zones. Other minerals include calcite, dolomite, magnetite, forsterite, micas (vermiculite, biotite, phlogopite, clinochlore) and silicates (microcline, cordierite, clinochrysotile). Despite of similarity of physico-chemical properties of Ca-minerals and auto-activation phenomena occurred in such complex system, the obtaining of a high quality commercial phosphate concentrate was complicated by the presence of 18 Mg-containing minerals.

The work presents the development of optimized blends of fatty acid based reagents with nonionic additives according to the specific mineral and textural properties of each sample in both direct and reverse flotation modes.

The use of a mixture of fatty acid and nonionic reagent as an alternative for nonylphenol ethoxylates during the flotation of old tailings considerably increased the apatite concentrate grade (27-20 %) with P2O5 recovery of 40-64 %. Coupling new reagent suites and intensive flotation approach can transform the fine fraction of old tailings to a secondary source of phosphate. The concentrate grade increased by 4-6 % P2O5 and the recovery level of 40-46 % from a deslimed at 7 µm feed was achieved after rougher and one cleaner stage in a pilot-scale column, while the concentrate grade increased to 32-36% P2O5 with a higher recovery level at 58-61 % using the blend of collectors and an intensive flotation machine.

The work performed allows to conclude that all samples tested can be regarded as future resources for additional phosphorus recovery. The approach developed was tested on the sedimentary ore samples and may be adapted to other low-grade igneous and sedimentary phosphate ores.