

ULTIMATE FLOTATION SPEARHEADING WORLD-CLASS FLOTATION TECHNOLOGY

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Ultimate Flotation share the feelings of aversion experienced by project owners when counting the cost of economic minerals reporting to plant tailings. For this reason our flotation technology is focused on maximizing mineral recovery efficiency whilst producing suitable mineral concentrates for the next process step. Ultimate Flotation and Foskor share the same passion and foresight to develop and introduce innovative and exciting technologies to complement our respective businesses. Foskor Phalaborwa bears witness to our accomplishments through which drastic improvements in phosphate recovery have been realized and significant savings in power and reagent consumption have transpired. An added bonus to Foskor is the substantial reduction in plant maintenance costs as observed by the longer lifespan of the Ultimate Flotation cell commodities.

Ultimate Flotation cells can be calibrated for optimal performance by means of adjustments on variable frequency drives fitted to the self-induced air mechanisms. The result is optimum slurry agitation and aeration without excess sedimentation of coarse solids. Due to the innovative design of our flotation mechanism, our flotation cells operate close to half the rotational speed of conventional flotation systems in general, with commensurate savings in power consumption. Our flotation mechanism draft tubes fed via cell to cell pulp transfer systems, facilitate direct presentation of the pulp to the impeller region of the mechanism.

Due to their unique and flexible design our flotation cells are suitable for the beneficiation of a wide range of minerals and can be deployed in rougher, scavenger, cleaner and re-cleaner applications. Their unsophisticated operability and simple maintenance requirements allow deployment of our flotation cells in remote locations where engineering resources are scarce.

Start-up of the Ultimate Flotation cells can be done under full load – no losses after planned or unplanned stoppages. The Ultimate Flotation cell overcomes the key inefficiencies of other similar flotation cells by facilitating stable, controlled, self-induced air at flow rates selectable for a range of pulp conditions whilst keeping the solids in suspension and yielding optimal froth surface stability. These features ensure optimal mineral recovery without noisy costly blowers and associated auxiliary equipment.

From the above it stems that the flotation technology of Ultimate Flotation equates to superior results at lower cost than any of our competitors.

Additional to supplying flotation equipment and turnkey flotation plants, we also undertake and orchestrate flotation test work on behalf of our clients, the results of which are used as input data for proper sizing of our client's flotation plants. Patented, tried and tested technology guarantees industry-leading recovery rates to help you reach your targets and maximise your investment.

NEW APPROACHES TO PHOSPHATE ORE BENEFICIATION COUPLING CHEMISTRY AND HYDRODYNAMIC OF FLOTATION PROCESS

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Key Words: Phosphate, francolite, tailings, carbonate, collector blend, intensive flotation machine.

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, clinocllore) and silicates (microcline, cordierite, clinochrysoile). 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.

BEST PRACTICES OF RUSSIA IN EXTRACTING REE FROM FERTILIZER WASTE

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Rare earth elements (REE) are as well classified as EU critical metals. The Finnish apatite minerals, industrially utilized for manufacturing phosphate fertilizers represent a potential secondary source of REE. In the current fertilizer manufacturing process even 80% of the REE will end up in the phosphogypsum (PG) side product, which then holds 0.15–0.5 % of REE. So far economical means of recovering REE from apatite or PG have not been found. Novel active extraction or ion exchange methods have been recently examined by UrFU.

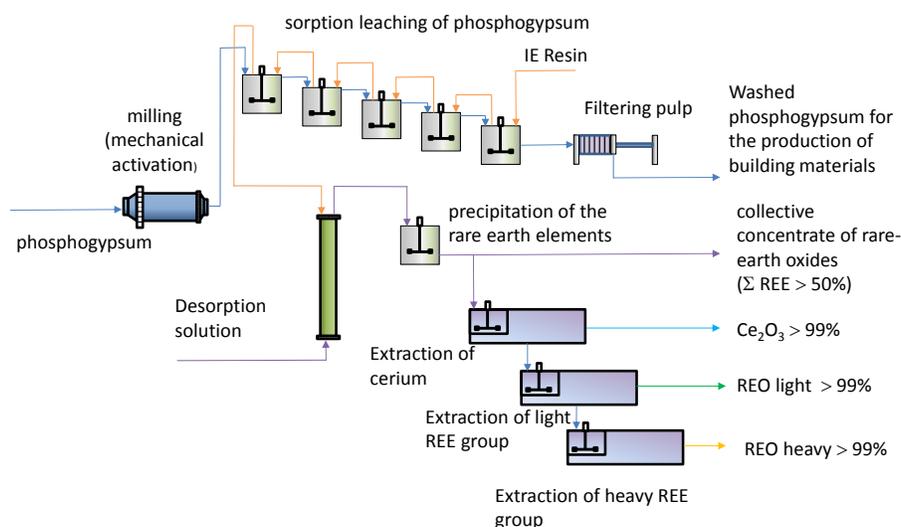


Figure 1 – The technological scheme of countercurrent REE recovery from PG

Sorption and extraction are currently the most promising methods for extracting REEs from dilute solutions, since they have a high-performance and simple hardware design. They are also selective and well suitable for construction of closed circulation. The REE from phosphogypsum have been recovered by counter current acidic sorption leaching as described in figure 1.

With sulfuric acid leaching and commercial cationites as sorbents extraction efficiency of 60-65 % has been gained. The respective minipilot has been operated continuously to process a batch of 45 tonnes PG. The REE concentrate obtained was ca 100kg's with 48-54 % of rare earth elements.

Desorption was carried out with a solution of ammonium sulphate. The choice of this reagent was dictated by the fact that further processing of the eluates will involve the use of ammonia and ammonium salts to precipitate functional groups in the adsorbent resin. To further refine the desorbed REE solution it was treated with 10% NH₄OH. Pre-neutralization of the excess acidity with ammonia was necessary, firstly, to help reduce the formation of ammonium carbonate salts, and secondly, to precipitate bulk metal hydroxides such as Fe³⁺, Al³⁺ simultaneously sorbed with REE. Precipitation led to pH 4.5-5. This interval is characterized by the end of the precipitation of hydroxides of the above metals. Precipitation of REE as carbonates is a well-known process and can be performed by use of ammonium carbonate. With this treatment, a recovery rate of 75-80 % of REE as Ce₂O₃ and light and heavy REM carbonate concentrates has been achieved with purity exceeding 99 % when up to 50 kg's of original REE concentrate solution has been treated.

BENEFICIATION OF ESTONIAN PHOSPHATE ORE BY FLOTATION

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Key Words: Estonian phosphorite, flotation, wet processing.

Sole active mining phosphate operation in European Union (EU) is in Finland Siilinjärvi with limited resources available for approximately next 20-30 years [1]. In this context it is important that Estonia holds the largest unused sedimentary phosphate rock reserve in EU. Estonian phosphate is a sedimentary rock composed of variegated sandstone that contains abundant remains (detritus) of (biogenic) phosphatic brachiopod shells [2]. Phosphate enriched beds occur stratigraphically at the transition between Cambrian and Ordovician and the phosphatic sandstones belong to Kallavere formation. The biogenic phosphate is dominated by francolite mineral phase. The P_2O_5 content of the sandstone beds is quite low varying between 6–20% [3]. However, the brachiopod shells and detritus contain up to 35–37% of P_2O_5 and sandstone is weakly cemented that allows rather efficient enrichment of the phosphate ore. Despite of its economical and, perhaps, political importance, Estonian phosphate rock is currently not mined or explored due to concerns over the ecological impact of phosphate rock mining. The main concern is on the environmental effects of the rock mining in the inhabited area with numerous settlements and intensive agricultural use.

In order to effectively separate phosphate from gangues froth flotation is often used as a beneficiation method [4]. It can be accomplished using anionic fatty acid as a collector for phosphate in direct flotation or cationic amine as a collector for quartz in reverse flotation or they can be used in combination as in the well-known “Crago” process used in the Florida phosphate industry. The difficulty in phosphate beneficiation arises from three factors: (i) in apatite lattice PO_4^{3-} are highly substituted for CO_3^{2-} ; (ii) the phosphate particle surface is porous and irregular leading to a larger surface area; (iii) sedimentary minerals such as phosphate contain more slimes than crystalline minerals and therefore, require the use of higher dosages of reagents in processing [5]. The complex flotation system involves three phases (solids/water/air) and the interaction of chemical and physical variables. To achieve the maximum result the individual enrichment complex should be worked out for every origin of phosphate ore.

Certain knowledge on the application of the wet process for Estonian phosphorite is originated from laboratory scale investigations at Tallinn University of Technology in the period of 1978-1985 [10-12]. There is a gap of at least 25 years in phosphorite geology/technology research in Estonia and this research field needs to be restarted to assess the economically and environmentally sound technologies to be used for Estonian phosphorite processing. Technological challenge for Estonian phosphorite rock (5-20% P_2O_5) processing is its preliminary beneficiation to the required level (28-32% P_2O_5). Deep beneficiation with flotation is the primary technology used for phosphorite ores. Estonian phosphorite is principally a siliceous phosphorite ore - sandstone that contains abundant remains of phosphatic brachiopod shells. For the floatable siliceous ores, typical beneficiation methods include anionic flotation of phosphate and anionic flotation followed by cationic flotation to further reduce silica content. Certain amount of data currently existing in the field of beneficiation of Estonian phosphorite rocks was generated and collected by research institutions of the former Soviet Union in the period of about 40 years ago. Also, a full-scale flotation plant operated in Maardu using Swedish cationic flotoreagents during some years in 1970-ies. The concentrate was used in the second stage of triple superphosphate production in Russia.

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