BENEFICIATION OF ESTONIAN PHOSPHATE ORE BY FLOTATION

Kadiiann Tamm, Laboratory of Inorganic Materials, Tallinn University of Technology, Estonia
kadiiann.tamm@ttu.ee
Indrek Plir, Laboratory of Inorganic Materials, Tallinn University of Technology, Estonia
Rein Kuusik, Laboratory of Inorganic Materials, Tallinn University of Technology, Estonia
Kaia Tõnsuaadu, Laboratory of Inorganic Materials, Tallinn University of Technology, Estonia

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 P₂O₅ 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 P₂O₅ 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 PO₄³⁻ are highly substituted for CO₃²⁻; (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 phosphate 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% P₂O₅) processing is its preliminary beneficiation to the required level (28-32% P₂O₅). 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 floreagents during some years in 1970-ies. The concentrate was used in the second stage of triple superphosphate production in Russia.