Minerals Engineering 187 (2022) 107768

Contents lists available at ScienceDirect

Minerals Engineering

journal homepage: www.elsevier.com/locate/mineng

Separation of lepidolite from hard-rock pegmatite ore via dry processing and flotation

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ARTICLE INFO

Keywords:
Lepidolite
Sorting
Electrostatic separation
Froth Flotation
Zero waste

ABSTRACT

A mineralogical study of Gonçalo lithium-bearing mica-rich pegmatite ore (Portugal) indicated that lepidolite occurs in coarse-grained textures, which allows an appreciable liberation of gangue minerals (quartz, k-feldspar, and albite) from lepidolite. However, the intergrowth of these gangue minerals results in uncomplicated liberation (i.e., inclusions). Taking advantage of this coarse gangue liberation, optical ore sorting through image analysis was attempted in order to predict the grades of different-sized fractions using a random comminution algorithm. The ore-sorting process allowed the production of a marketable Li pre-concentrate product for metallurgy. Moreover, this method also highlighted the possible valuation of the reject as low-Li-content quartz–feldspar mixtures for the ceramic industry (reduction in the temperature of porosity closing). Furthermore, a scaled approach of grinding and sieving allowed the formation of a lepidolite-rich fraction (>210 μm), which was processed using an electrostatic separator by varying key process parameters. The lepidolite and muscovite were separated to obtain a Li pre-concentrate assaying 3.5 % Li_2O from a feed grade containing 1.8 % Li_2O. Nevertheless, according to the zeta-potential measurements, the flotation test performed with the finer-sized fraction (–210 + 63 μm) showed that lepidolite flotation was optimised between pH 3 and 5. In this pH range, concentrates from the rougher stage assayed 4.2–4.5 % Li_2O, corresponding to 87–95 % Li recovery. At pH > 5, the selectivity decreases, and SiO_2 analysis suggests the flotation of quartz and other silicates rather than lepidolite. Feldspar/quartz flotation was also tested using lepidolite flotation rejects to promote the separation of feldspars from quartz and obtain products for ceramic applications.

1. Introduction

Lithium (Li) is an essential element for energy production and storage in modern energy-transition systems (Li-ion batteries, etc.). However, lithium is also mandatory in other applications such as the ceramics, glass, lubrication, and pharmaceutical industries owing to its unique electrochemical properties and high specific heat, which is the highest of all solid elements (Meng et al., 2021; Naumov and Naumova, 2010; Penner, 1978; Salakjani et al., 2019; Swain, 2017). Recently, lithium has gained importance under the "critical material" category owing to the rapidly increasing demand for green energy-storage technologies (European Commission, 2020); therefore, it is listed as a promising energy source in the World Bank survey. In addition, it has been prospected that its demand will increase in many fields in the future (Bach, 1985; Chagnes and Światowska, 2016; Kim et al., 2013, 2014; Scrosati et al., 2015).

Brines and crystalline rocks (i.e., granites, pegmatites, and greisens) enriched in Li-silicate minerals and/or phosphates are the main sources of lithium (Kesler et al., 2012; Penner, 1978; Gruber et al., 2011). More than 20 lithium-containing minerals have been identified in Earth's crust (Christmann et al., 2015; Garrett, 2004). However, only some of them have commercial/industrial utility: lepidolite, spodumene, petalite, amblygonite–montebrasite, and zinnwaldite (Sadoway 1998, Levich 2009). Most mineral deposits benefit from flotation as one of the major separation processes (Bhappu and Fuerstenau, 1964; Bulatovic, 2015; Filippov et al., 2019; Tadesse et al., 2019). The most important type of crystalline-rock lithium deposit is pegmatite (Tkachev et al., 2018). The world's largest source of lithium pegmatite is the Kings Mountain pegmatite belt in North America, where 62.3 Mt of the mineral is deposited (averaging 0.67 % or 0.42 Mt of Li). Greenbushes is the largest

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https://doi.org/10.1016/j.mineng.2022.107768
Received 19 January 2022; Received in revised form 23 June 2022; Accepted 26 July 2022
Available online 13 August 2022