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Quantitative characterisation of processed phlogopite ore from Silver City Dome District, Kansas, USA, by automated mineralogy

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Abstract

Historically, phlogopite and olivine have been mined in the Silver City Dome District in Kansas, USA, from lamproite ultra-potassic igneous rock for use as a supplement in cattle feed. Micro-Lite LLC is now evaluating processing techniques for recovery of phlogopite to be used for reinforcement in plastics, high temperature applications, and electrical insulators, which requires a higher grade phlogopite product. To determine the purity of the processed ore, QEMSCAN® was utilised to identify and quantify phlogopite and impurities, including olivine, pyroxenes, feldspars, titanium phases (mainly titanite and perovskite), apatite, magnetite, chromite, and other phases. Samples were prepared and analysed in a manner to decrease or eliminate preferred orientation of phlogopite to provide accurate quantitative results. The results show that the flotation product has a higher concentration of phlogopite at 87% (by mass), compared to 78% in the hydrosizer product. The main impurity phase in both products is olivine (10% in the flotation product and 18% in the hydrosizer product). In the hydrosizer product, 15% of the sample consists of liberated phlogopite particles, while in the flotation product 58% of the sample occurs as pure, liberated phlogopite particles.

Keywords: Industrial minerals; Flotation; Hydrocyclones; Liberation analysis; Ore mineralogy

1. Introduction

Industrial minerals are important in a multitude of applications. Phlogopite is an industrial mineral that is mined for use in various applications, mainly because of its beneficial chemical and physical properties, such as outstanding electrical properties, temperature resistance, and UV light absorption. These properties make it a useful resource for many practical applications, including high temperature insulation, reinforcement for high-density polyethylene and polypropylene plastics, electrical insulation, natural lubricant, and additives in cosmetics.

This paper covers the findings of a quantitative mineralogical study performed on two products from a pilot plant, initiated by Micro-Lite LLC, to extract a pure phlogopite product from a lamproite deposit in Kansas, USA, for use in such industrial applications, to gain an understanding of any processing issues present in the pilot plant.

2. Geological setting

The Silver City Dome District is located in the Osage Cuestas near the Chautauqua Hills in Woodson County, south-eastern Kansas, USA (Fig. 1). The surface area is composed of sedimentary rocks, primarily limestones and shales, of Pennsylvanian age (300 Ma). Lamproite pipes (Mitchell and Bergman, 1991; Rock, 1991), composed of ultra-potassic igneous rocks, intruded 100 million years ago and are present as eroded domes at the surface at

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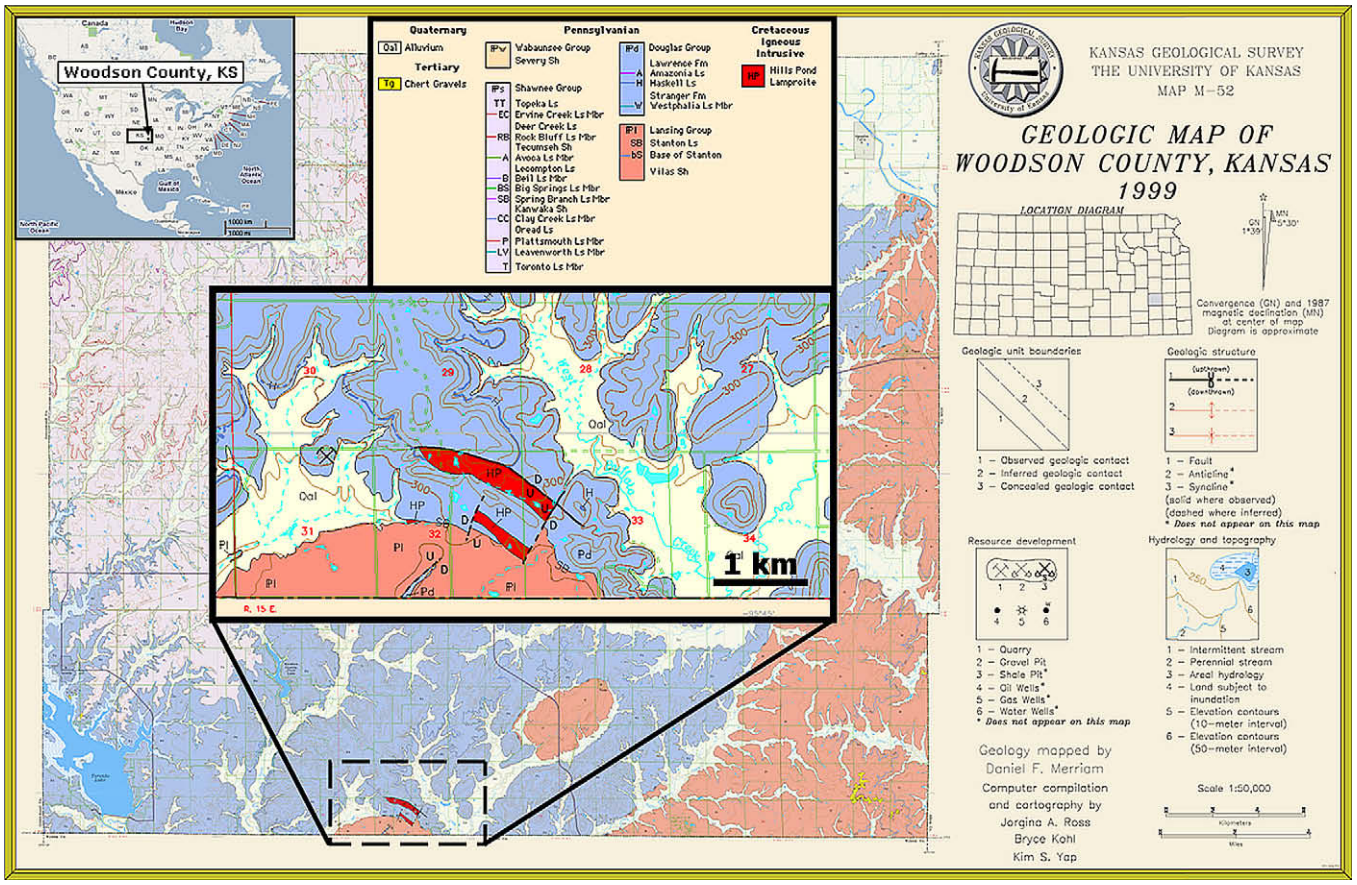

Fig. 1. Geological map of Woodson County, Kansas, USA, with the Silver City Dome lamproite (shown as Hills Pond Lamproite – HP) in the enlarged map (modified after Merriam, 1999).

two locations in this vicinity: Rose Dome and Silver City Dome. These particular lamproites are geologically known as the Hills Pond lamproite (Wagner, 1954), and characterised by high K_2O/Na_2O ratios that are typically greater than 5. Horizontal sheets of lamproite sills are evident at a depth of 400 m surrounding the Silver City Dome. Precambrian granite igneous xenolith rock fragments associated with the lamproite pipes have been dated at 1.2 billion years old (Berendsen, 2007; McCauley et al., 2002).

The Silver City Dome lamproite mainly consists of anhedral olivine (~75%), which may be partially or completely altered, and euhedral to subhedral reddish-brown phlogopite (up to 20%). Minor constituents (typically <5%) of the lamproite are diopside, K-richterite, rutile, apatite, perovskite, and spinel group minerals, which also make up the fine-grained groundmass (determined by optical microscopy).

3. Mining history

Silver City obtained its name in the late 1800s when the shiny flakes of mica in the lamproite were mistakenly identified as silver, creating a short period of mining activity. Although no silver is present, the area has been mined on and off over the years. From 1961, the lamproite was mined for use in industrial applications. Since 1982, Micro-Lite LLC has been mining approximately 70,000 tonnes/yr of lamproite from the Silver City Dome in sills up to 35 m thick, which has been used as a supplement to cattle feed for the essential elements Mg, K, and Fe.

4. New pilot plant

In 2005, tests were initiated by Micro-Lite LLC to extract the phlogopite from the lamproite for use in industrial applications. The testing resulted in the construction of a pilot plant utilising hydrosizer and flotation separation methods, to concentrate the coarse and fine phlogopite, respectively. The mineral processing in this pilot plant consists of the following steps: firstly the raw ore is reduced in size using a ball mill. The milled ore is then separated into a fine and coarse product using a hydrosizer. The coarse product consists of large phlogopite flakes, up to a few millimetres in size, and is the first end-product (the "hydrosizer product" analysed in this study). The fine hydrosizer product is fed into an attrition scrubber to remove clay from the ore. The cleaned product goes into the flotation process where phlogopite is floated. The resulting flotation product is the final product, which was also analysed in this case study (Fig. 2).