ELEMISSION

LIBS TECHNOLOGY

APPLICATION NOTE

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STREAMLINING COPPER EXPLORATION AND PRODUCTION WITH ECORE

ECORE

Differentiating spodumene and petalite from lithium-bearing pegmatites using ECORE

Keywords: **Spodumene, Petalite, Drill Core, Lithium, Lithium-Ion Batteries**

Instruments: **ECORE, ECORE Flex**

Importance of Li-Minerals

As policymakers work towards a more sustainable future, the demand for green technology has grown. Lithium is a crucial metal for the global energy transition, as it is used in lithium-ion batteries. As these batteries are rechargeable, they can be used in many different settings including communications, entertainment, electric bikes, cars, and for solar power backup storage. Thus, both the exploration and production of lithium need to meet the increasing global demand.

In nature, over 120 mineral species contain lithium as an essential constituent, and 44% of them can be found within lithium-cesium-tantalum pegmatites, the most important economic source of lithium globally (Grew, 2020). Besides also being rich in other light elements such as K, Rb, Cs, and Be (Fig. 1), these pegmatites host spodumene ($LiAlSi_2O_6$) and petalite ($LiAlSi_4O_{10}$), the most important lithium minerals for economic use. Once lithium is extracted, it finds use in the production of ceramics, glass, the manufacturing batteries and more.

Table 1. Chemical composition of spodumene and petalite in wt. % element

Element	*Spodumene*	*Petalite*
Li	3.73	2.09
Al	14.50	8.75
Si	30.18	36.72
O	51.59	52.43
Total	100.00	100.00

Both minerals, spodumene and petalite, contain extractable lithium; however, spodumene is generally considered more favorable due to several advantages. Firstly, spodumene contains a higher lithium concentration than petalite (Table 1), leading to increased yields of higher-grade lithium concentrate (Su et al., 2019). Its lower hardness facilitates easier crushing and processing compared to petalite. While both minerals are soluble in sulfuric acid, spodumene's significantly lower acid consumption makes it more economically viable (Meshram et al., 2014). Despite petalite containing lithium, spodumene's efficiency and cost-effectiveness in extraction and processing make it the preferred choice. Thus, accurately estimating mining, processing costs and overall economic viability necessitates a comprehensive understanding of the contributions of different lithium minerals in deposits.

In this application note, we present how ECORE technology can help distinguish spodumene from petalite and quantify lithium in pegmatitic lithologies as a function of depth along drill cores.

APPLICATION: Pegmatite Drill Cores

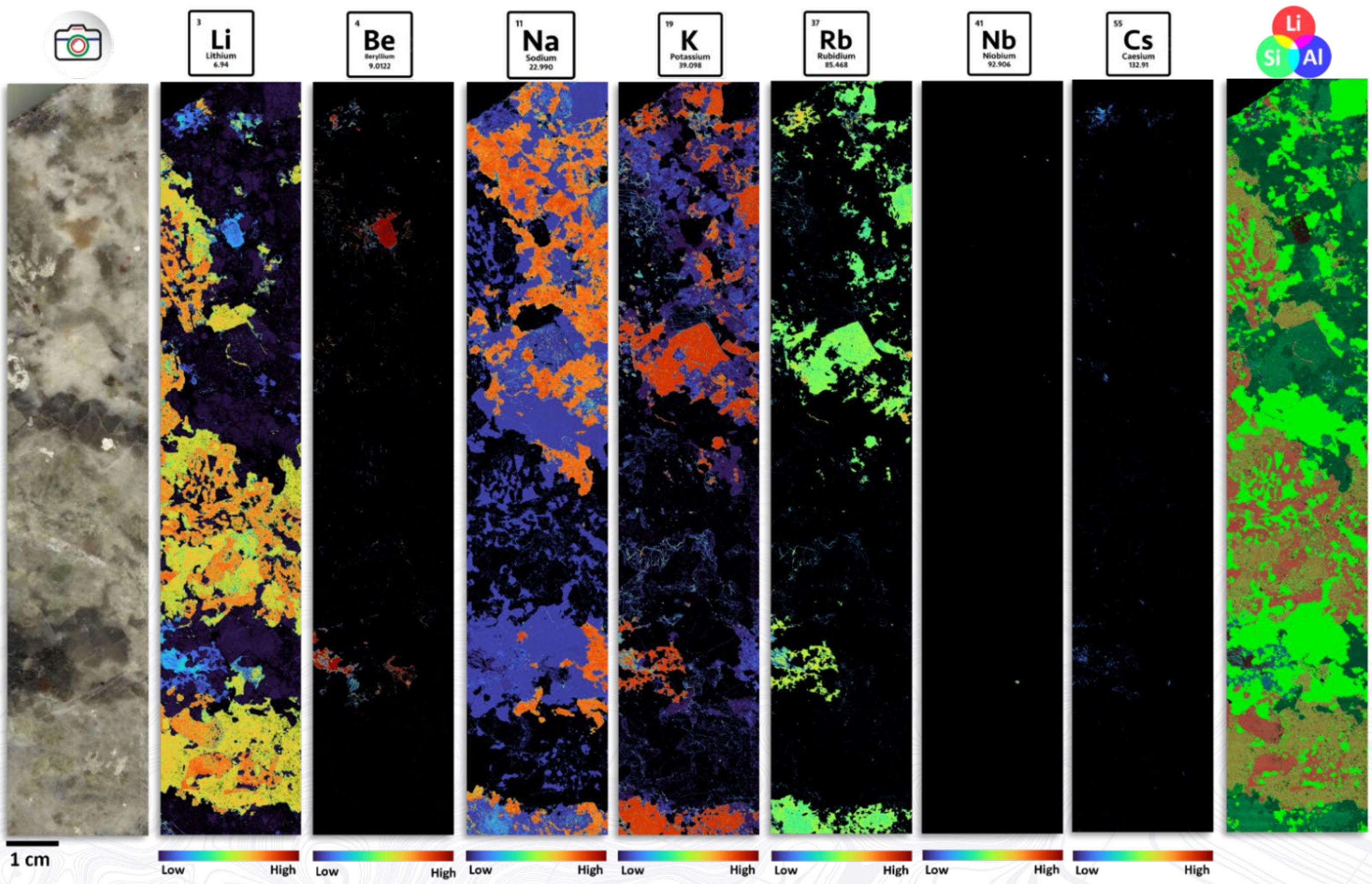

Figure 1: Photograph, elemental maps, and stacked elemental maps (RGB) of a lithium bearing pegmatite.

Laser Induced Breakdown Spectroscopy (LIBS), interchangeably referred to as Laser Ablation Atomic Emission Spectroscopy (LA-AES), is a spectroscopic technique that utilizes laser ablation to excite elements in a material. Our ECORE technology employs this method while acquiring spectral data while scanning of drill core surfaces. With each laser pulse, a plasma is created, and as the plasma cools, the emitted light is captured by a spectrometer. This process generates a characteristic spectrum of each material ablated along the surface containing elements that are present in the material.

1. Elemental Maps

During the data acquisition, ELEMISSION's proprietary software enables simultaneous examination of results. The software's user-friendly interface has the capability to generate both mono- and multi-elemental maps of surfaces scanned by ECORE (Fig. 1). ECORE exhibits high sensitivity to light elements, yet it can detect nearly all the naturally occurring elements. Thus, the generation of elemental images facilitate the visualization of elemental behavior and associations within samples. RGB mapping (Fig. 1) highlights even minor variations in chemical compositions, aiding in the differentiation of minerals with similar compositions. In the RGB map (Fig. 1), spodumene (orange) is easily distinguishable from petalite (bright red) within a drill core section from a lithium pegmatite deposit. These maps can be generated within minutes for entire core boxes, allowing for rapid and efficient interpretation and quick decision-making during the extraction process.

2. Automated Mineralogy

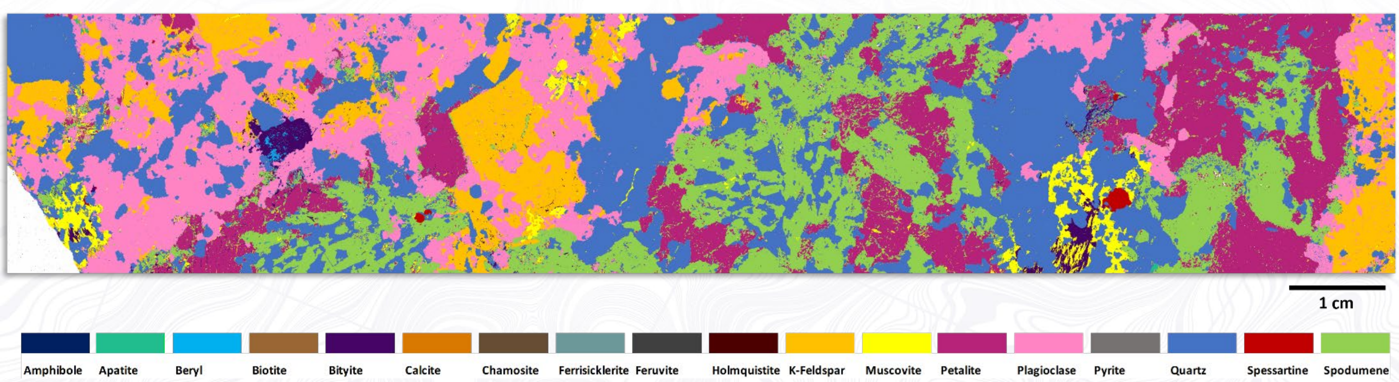

Figure 2: Smart Automated Mineralogy (SAM) map of identified minerals in a pegmatite, including lithium bearing minerals, such as petalite and spodumene.

Besides the advantage of generating elemental maps, ELEMISSION's Smart Automated Mineralogy (SAM) learning algorithm allows for the automated and precise creation of mineralogical maps. This algorithm consistently recognizes lithological units and their unique mineralogy. Figure 2 displays a high-resolution SAM image of a small drill core selection from a lithium pegmatite deposit. In this instance, the software's algorithm identifies and distinguishes 17 minerals. The SAM image provides valuable and detailed information on texture and mineral associations, enhancing interpretative capabilities, accuracy of logging, and the development of mining strategies.

3. Chemical Assay

Using ECORE technology, chemical assays can also be provided in real time. Figure 3 shows ECORE chemical assays taken at 1-meter intervals over a 1500 m-long drill core from a lithium pegmatite deposit. The chemical assay results obtained through spectroscopy with ECORE are compared to assays obtained by a standard laboratory method (ICP-AES, 4 acids). The R^2 value (0.98) and the slope of the curve (0.99) reveal a very strong correlation between these two methods and demonstrate that ECORE is equally effective and reliable compared to traditional laboratory methods. Immediate access to quantitative chemical data, generated as a function of depth in intervals of the user's choice, is invaluable for expediting decision-making processes. This capability eliminates the conventional weeks- or months-long delays typical when awaiting results from traditional laboratory assays.

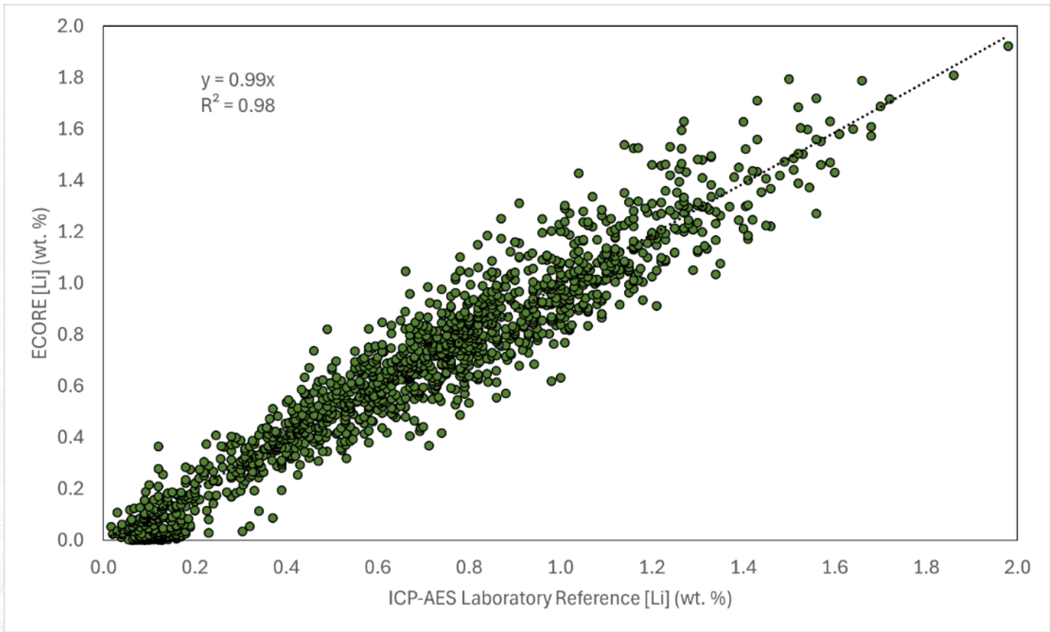

Figure 3: Chemical composition of lithium (in wt.%) from various pegmatitic rock samples comparing ECORE with ICP-AES laboratory analyses.

APPLICATION: Rock Chip Analysis

ECORE exhibits versatility by extending its capability beyond intact drill core analysis; it can also analyze crushed core samples, rock chips, and powders as pressed pellets. Figure 4 showcases stacked elemental and mineralogical (SAM) maps from rock chips collected from a lithium pegmatite deposit. This adaptability allows for a comprehensive understanding of the material's composition across different forms, providing valuable insights into elemental distribution and mineralogy beyond the traditional analysis of intact drill cores. This flexibility benefits applications such as quality control during production cycle, tailing assessments and more.

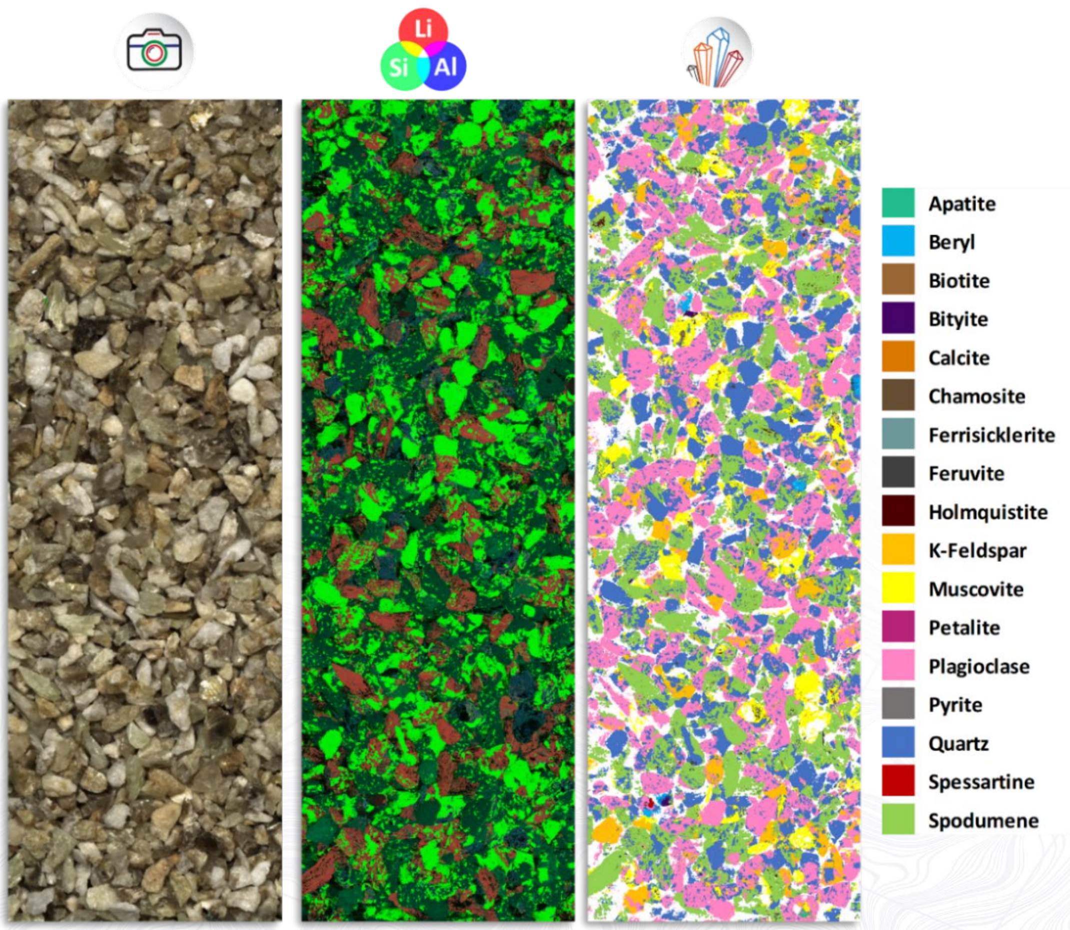

Figure 4: Rock chips obtained from a lithium pegmatite deposit are depicted, featuring a photograph, RGB mapping, and a mineralogical (SAM) image. The legend corresponds specifically to the SAM image, providing a comprehensive overview of the mineralogical composition and enhancing the visual data interpretation.

Conclusion

The increasing demand for lithium, driven by the growing need for sustainable energy solutions, underscores the significance of efficient exploration and production methods in lithium-bearing pegmatites. Spodumene and petalite, both key lithium minerals, play a vital role in meeting this demand. While both minerals contain extractable lithium, the distinct advantages of spodumene make it the preferred choice for economic use.

This application note highlights the pivotal role of ECORE technology in differentiating spodumene and petalite within lithium pegmatites. The elemental maps generated by ECORE provide a rapid and efficient means of visualizing and distinguishing minerals with similar compositions. The technology's versatility is showcased by its ability to analyze various forms of samples, including intact drill cores, crushed core samples, rock chips, and powders, offering a comprehensive understanding of elemental distribution and mineralogy.

Moreover, the automation capabilities of ELEMISSION's Smart Automated Mineralogy (SAM) learning algorithm contribute to precise mineralogical mapping, enhancing interpretative capabilities, logging accuracy, and the development of effective mining strategies. The real-time chemical assays provided by ECORE, with a strong correlation to traditional laboratory methods, eliminate the delays associated with conventional assays, facilitating quicker decision-making processes. In summary, ECORE technology emerges as a valuable tool in the exploration and production of lithium, contributing to the industry's efficiency, accuracy, and overall economic viability.

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