LIBS-SCReeN

Screening Critical Raw materials from exploration to (post)beneficiation using New LIBS techniques

DURATION
15/12/2020 - 15/03/2024

BUDGET
1 024 594 €

PROJECT DESCRIPTION

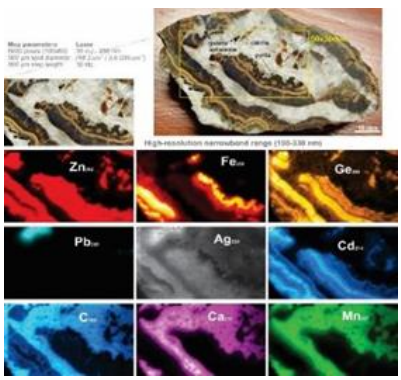
CRM – A societal challenge

Meeting the growing need in Critical Raw Materials (CRM) is one of the greatest challenges for the next decades in EU and beyond. In this context, resource availability is one part of the problem. Another issue is the environmental impact of mining and processing, incl. recycling CRMs. Highly flexible, rapid and reliable measurement techniques are needed to enhance our capacity of pollutant-free CRM exploration and exploitation in various environments.
LIBS-SCReeN will be devoted to the optimization and application of Laser-induced break-down Spectroscopy (LIBS) techniques for multiscale detection and characterization of CRM, with emphasis on the Belgian lead-zinc deposits. This type of mineralization is known worldwide to potentially host germanium, gallium, indium and cadmium. In Belgium we know the potential for germanium. Conversely, mining and processing activities linked to Pb and Zn can contaminate the environment. Cd is a major contaminant of soils in Belgium. Moreover, the project will strengthen Belgium's expertise in LIBS, which is currently dispersed among federal institutions and universities. Creating a Belgian LIBS research cluster will be of added value.

LIBS as high-potential versatile technique

LIBS (Laser-Induced Breakdown Spectroscopy) is a technology of choice for exploring and recycling CRM, and monitoring the environment of sites associated with the Raw Materials economy. This emission spectroscopy technique uses high-energy laser pulses to induce a plasma from solid, liquid or gas samples. The plasma emits specific light wavelengths related to the chemical composition of the target material with specific spectral lines for each element contained in the plasma and thus in the sample. The technique has huge advantages, i.e. it is fast and very flexible, it needs a minimum to no sample preparation, it can be performed in air under normal pressure, no need for vacuum, and therefore can be declined in portable versions. Moreover it can be applied in many configurations, with point-and-shoot, line and area scanning capability, from microscopic to field scale, and even remote with a distance up to tens to hundreds meters.

LIBS instruments typically achieve fast and sensitive analysis, with micro to milliseconds analytical time per single laser shot and detection limits ranging from ppm to ppb. However, this relatively young technique still needs firm scientific foundations for reliable data processing and interpretation, as well as optimization of the design and the settings of the experiments.



Example of geochemical mapping using LIBS of Pb-Zn ore samples from Andenne, Belgium. (UMONS collection).

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Samples and methodology

Our study will focus on the lead-zinc deposits of Belgium and associated industrial sites: former mining plants, ore processing wastelands, and primary and secondary ore materials. Ore materials will be collected in the field as well as in the collections available at Royal Belgian Institute of Natural Sciences, ULg and UMONS. LIBS-SCReeN will test the potential of CRM associated with these deposits that were previously estimated as economically interesting for germanium (and cadmium). Besides characterisation of ore deposits, contaminated soils at the post-industrial heritage sites such as Prayon and Sclaigneaux linked with the extraction of Pb-Zn ore deposits, will also be investigated. Thanks to the complementarity of the expertise and instrumentation of the three laboratories, several reference materials will be tested in different settings and at different scales (spot and line measurements, 2D mappings and remote on the field) to optimize the measurement procedures and settings.

The combination of hyperspectral imaging (VNIR-SWIR) and LIBS spectrum provide typically complementary rich information about both crystalline structure and elemental content. Reference measurements (performed either with SEM, or XRD) will provide mineralogical information. The data will be used as ground truth to train convolutional neural networks, converting the spectral data to an estimation of the mineralogical content.

The large number of spectral data generated during this study will feed one of the research cornerstones of this project: the application of artificial intelligence, especially application-oriented deep-learning chemometrics to automatize treatment of LIBS data streams. The performance of basics methodologies in machine learning (ML) and pattern recognition (linear discriminant analysis, artificial neural networks, support vector machines, etc.) and advanced ML including extensions to specific multivariate analysis methodologies and deep learning will be assessed. With the expertise of KULeuven Institute for Artificial Intelligence, LIBS-SCReeN will thus pioneer a geoscience deep-learning application for CRM's screening at a country scale.

Field deployable-remote LIBS instrumentation. (a) RBINS-GSB, (b) and (c) SETI-CSC

Attended outputs from the project are:

- The demonstration of the ability of LIBS to perform fast and accurate screening of Pb-Zn deposits and associated processing sites in Belgium, including soils, for heavy metals (Zn, Pb, Co, Cd, Ag, Ge), and metalloids (As) with ppm level limits.
- Science-driven strategies to exploit LIBS for CRM screening at multi-scale: ore samples (e.g., mineralogical and geochemical mapping), cores (multi sensors fast ore screening) and field, (e.g., ground survey with georeferenced mappings).
- A Belgian LIBS cluster, that is connected to the global scientific LIBS community and the current EU projects and that promotes Belgian LIBS expertise internationally.

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LINKS

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