Data release from critical companion metals study of the past-producing Sullivan Pb-Zn-Ag mine, East Kootenays, British Columbia

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Front Cover:
Reflected light photomicrograph showing isoclinal folding of banded sphalerite (medium grey), pyrrhotite (light brown), galena (light grey), and garnet-rich siliciclastic layers (dark grey). Sample is from the 'C Band' of the bedded ore sequence at the past-producing Sullivan mine.

Back Cover:
Thin section backscatter electron (BSE) image and false-colour mineralogy from scanning electron microscopy-mineral liberation analysis (SEM-MLA) shows predominantly sphalerite (blue) with lesser galena (burgundy) and concentrated boulangerite, which defines an open fold ($Pb_5Sb_4S_{11}$, pink). Sample is from the 'Main Band' of the bedded ore sequence at the past-producing Sullivan mine.

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https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/british-columbia-geological-survey/publications

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Abstract

This contribution provides micro-analytical data to support ongoing critical companion metal studies in sediment-hosted Pb-Zn deposits in British Columbia. The data are from the past-producing Sullivan mine, in the Purcell basin of southeast British Columbia, and include: 1) micro X-ray fluorescence (μXRF) elemental concentration maps; 2) mineral abundance data and mineral maps determined by scanning electron microscopy-mineral liberation analysis (SEM-MLA); and 3) trace-element concentrations and elemental maps from laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) grain mapping of pyrite, sphalerite, garnet, galena, boulangerite, and cassiterite.

Keywords: Sediment-hosted Pb-Zn, SEDEX, critical metals, critical minerals, companion metals, Sullivan, Purcell basin, indium, cassiterite

1. Introduction

Primary commodities Pb, Zn, and Ag are commonly mined from sedimentary exhalative (SEDEX) deposits in deep-water siliciclastic successions. These deposits may also contain many minor 'companion metals' (Mudd et al., 2014, 2017; Nassar et al., 2015) that are on the critical minerals lists of different political jurisdictions (e.g., Hickin et al., 2024), including the 2024 iteration of the Canadian list (NRCan, 2024). These critical companion metals (e.g., Bi, Ga, Ge, In, Sb, Sn, Te) could conceivably be recovered as byproducts of primary commodity mining (e.g., IGF, 2023). The British Columbia Geological Survey is undertaking work to better understand the concentrations and mineralogical hosts (i.e., deportment) of critical companion metals in sediment-hosted Pb-Zn deposits in British Columbia.

This data release (BCGS GF2026-07.zip) includes petrographic and micro-analytical images for ore samples from the Sullivan mine, for which whole-rock lithogeochemical data were previously released (Graham and Ootes, 2025). Appendix 1 provides elemental concentration maps for 12 thin sections from micro-X-ray fluorescence (μXRF) in layered .pdf files; the user can toggle layers to view available elements. Appendix 2 provides modal mineralogy data (area %) derived from scanning electron microscopy-mineral liberation analysis (SEM-MLA) for seven thin sections. Appendix 3 includes false-colour mineral maps and backscatter electron (BSE) images from SEM-MLA analysis along with geochemical spider diagrams showing metal enrichment relative to the average composition of upper continental crust (Rudnick and Gao, 2014). Appendix 4 provides mean elemental concentrations and uncertainties from LA-ICP-MS mapping of mineral grains including sphalerite, galena, cassiterite, boulangerite, and garnet (Ootes et al., 2026). Appendix 5 provides the corresponding elemental concentration maps from LA-ICP-MS analyses from two thin sections, each with four mapped areas. Appendix 6 comprises elemental concentrations from the mapped areas overlain on images of the entire thin sections (reflected light photomicrograph from Zeiss Axioscan and SEM-MLA imagery). Appendix 7 includes supplementary imagery and synthesis of data from different methods for selected samples.

2. Methods

2.1. Sample selection

Hand samples of Sullivan ore (n=12) were retrieved from the BCGS rock archive (Rukhlov et al., 2023). Geochemical results from these rocks are presented in Graham et al. (2025) and Graham and Ootes (2025). For selected samples that yielded enrichment in critical companion metals, sample offcuts were prepared as polished thin sections which were scanned using Zeiss Axioscan petrographic imagery instrumentation.

Petrographic analysis was used to select samples for further analysis including SEM-MLA and μXRF. For elemental distribution (e.g., Sn, In) that could not be resolved by these methods, samples were selected for LA-ICP-MS elemental grain mapping.

2.2. Petrography

Polished thin sections were prepared and automated petrographic images were created using Zeiss Axioscan Geo7 at The University of British Columbia (UBC), Mineral Deposits Research Unit (MDRU). These images include plane, polarized, circular polarized, and reflected light photomicrographs. This imagery is viewed online and, with real-time pan and zoom functionality, allows the petrographer to conduct thin-section-scale to micron-scale mineralogical and textural evaluation of samples and immediate comparison with other datasets.

2.3. μXRF

A Bruker TornadoPlus μXRF instrument fitted with two 60 mm^2 detectors, housed in the MDRU at UBC was used for analysis. An Rh X-ray tube, excited to 50 kV and 600 nA current generates X-rays, which are focused through a polycapillary X-ray optic on the sample. The X-ray spot generated has a diameter of ~19 mm. Data were collected with a spatial resolution of 50 mm (generating images with a pixel resolution of 50 by 50 mm), with a counting time of 10 ms per pixel, typically generating several thousand X-ray counts per pixel. Sampling occurs as a sequential line scan, whereby the 19 mm spot moves along the sample as the instrument stage travels from left to right, the stage then steps back to its starting point, travels 100 mm down, and then travels left to right again. Data were processed in Bruker ESPRIT® software. In the software, a colour stretch is applied to count data so that higher counts appear as brighter colours producing intensity maps. Finally, a fundamental parameter (FP) method in Bruker ESPRIT® software was applied to each map to quantify results, which accounts for peak overlaps and background corrections. Because no standards were analyzed with unknown samples, the results should be treated as semi-quantitative, with significant uncertainties on any individual pixel. However, the fundamental parameter method has the advantage that it helps the viewer to determine likely 'true' variations in element intensities in a sample by removing variations in count rates caused by sample geometry and colour stretches, which are applied across very low count rate elements. Colours outside the edge of the sample represent artefacts introduced by the background substrate of the samples and are considered inaccurate. Elemental concentration maps are provided in Appendix 1.

2.4. Scanning electron microscopy-mineral liberation analysis (SEM-MLA)

Automated mineralogical mapping using SEM-MLA was conducted at CREAIT Microanalysis Facility (MAF), Memorial University of Newfoundland. Polished thin sections were mapped using a scanning electron microscope with derived backscatter electron (BSE) images and quantitative mineral abundance maps by mineral liberation analysis. The SEM work used a FEI MLA 650 field emission gun SEM equipped with two Brucker silicon drift EDS detectors. Operating conditions included 25 kV accelerating voltage for BSE images. Operating conditions for MLA included a 25 kV accelerating voltage, 10 nA current, and a 5.85 electron beam spot size. Thin sections were measured in GXMAP (grain-based X-ray mapping) mode where X-ray analyses were triggered for a BSE range of 40 to 255. Each X-ray measurement was acquired for 12 ms on a 1.5 by 1.5 mm frame with a resolution of 500 by 500 pixels per frame and an imaging scan speed of 16 μsec. Data reduction was performed on MLA Data View (FEI) software version 3.1.4.683. Appendix 2 provides quantitative mineralogy data in the form of area % for each mineral phase identified in a thin section. Appendix 3 provides BSE and false-colour mineralogy images from the SEM-MLA analysis, and mineral maps that have been generalized using in-house Python™ coding.

2.5. Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS)

To support the SEM-MLA and μXRF results, the metal distribution was mapped by LA-ICP-MS analysis in the Department of Earth Sciences, University of New Brunswick. Two samples with high In were targeted (Ootes et al., 2026), and in each thin section four sub-areas were chosen based on textural and mineralogical diversity. Trace-element raster maps were acquired using an Applied Spectra Inc. (ASI) RESOlution 193 nm laser ablation system connected to an Agilent 8900 QQQ-ICP-MS. A Norris Scientific 'fast-funnel' and Quadlock™ device were used to achieve fast washout and eliminate spectra skew. Rectangular areas of interest were ablated using a series of raster lines space at 25 mm and using a laser beam diameter of 26 mm, a pulse rate set by the Quadlock system (18-19 Hz), and a stage scan speed of 60 mm/s. The ICP-MS was set to collect a suite of 24 elements (^{24}Mg, ^{27}Al, ^{29}Si, ^{31}P, ^{34}S, ^{39}K,^{44}Ca, ^{47}Ti, ^{55}Mn, ^{56}Fe, ^{63}Cu, ^{66}Zn, ^{71}Ga, ^{73}Ge, ^{75}As, ^{107}Ag, ^{111}Cd, ^{115}In, ^{118}Sn, ^{121}Sb, ^{125}Te, ^{208}Pb, and ^{209}Bi) with a total quadrupole sweep time <0.25 s. The instrumentation was tuned on NIST610 glass to obtain oxide production ($^{248}ThO/^{232}Th$) <0.2%, doubly charged production ($22M/^{44}Ca$) <0.2%, and $^{238}U/^{232}Th$ of 1.02. Standards USGS BCR2-G and MASS-1 were also measured throughout the run to act as primary and secondary standards.

Trace-element maps were produced offline using Iolite4 (Paton et al., 2011; Paul et al., 2012; Petrus et al., 2017) and the 3D Trace-element Data Reduction Scheme (Paul et al., 2023), which includes a normalization to 100% calculation approach that obviates the need for internal standardization. The 3D Trace-element Data Reduction Scheme also includes a criteria function to parse mineral phases based on major-element compositions (e.g., Pb for galena; Zn for sphalerite; Fe for pyrite and pyrrhotite; Sb for boulangerite; Si for silicates; Sn for

cassiterite; Paul et al., 2023). This allows full quantification of trace-element maps based on observed mineralogy. Mean concentrations are derived from circular regions of interest selected on several examples of each mineral in the laser map and are provided in Appendix 4. Appendix 5 provides trace-element maps for the eight areas analysed, and Appendix 6 shows the maps in their corresponding locations on the two thin sections. Appendix 7 provides supplementary material and comparison between methods for selected samples.

Acknowledgments

This work follows and expands on a workflow established by Stephen Piercey.

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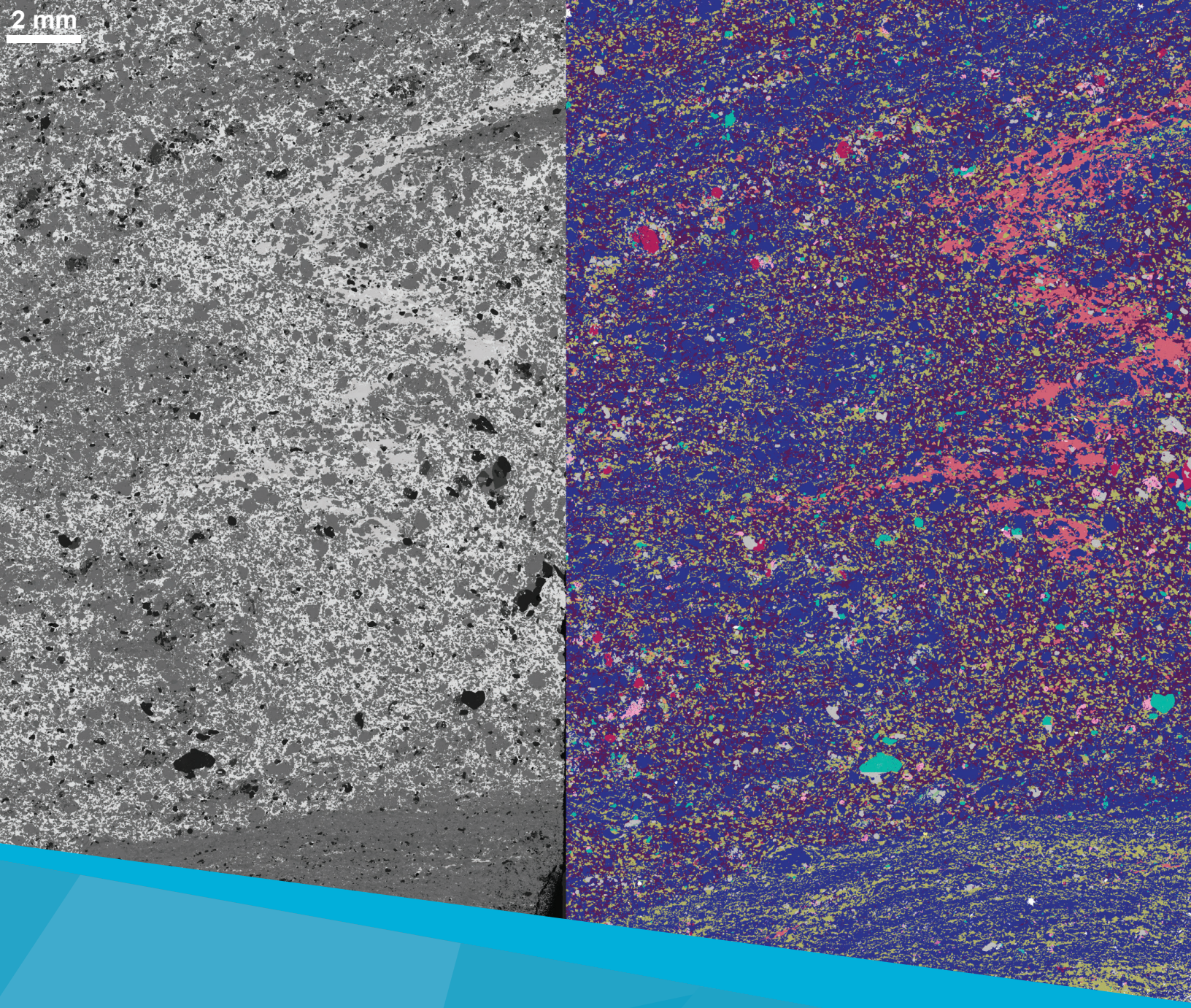

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