Coupled in situ galena trace-element and Pb isotope mapping: discriminating trace metal sources in VMS settings

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A method to acquire simultaneous trace-elements (Ag, Cd, Sb, Sn, Tl, etc.) and Pb isotope ratios in galena has been recently developed and tested by using a novel laser ablation quadrupole-ICP-MS methodology. Under optimized collection conditions, 20 replicate analyses on the same galena grain using an 80µm diameter crater yield a weighted mean 2σ precision of 0.1%. This level of precision is appropriate for identifying the source of Pb incorporated into galena relative to different Pb isotope reservoirs and deposit-scale isotopic arrays. Importantly, variations in trace-metal concentrations and metal ratios can be directly related to these Pb reservoirs or to mixing models between isotopic endmembers. The method can also be adopted to utilize loose fragments of galena, further enhancing the cost-effectiveness of campaign-style regional investigations.

This talk will: (1) demonstrate the general methodological considerations related to this method; (2) explore some of the results obtained for well-studied VMS, vein-style, SEDEX, and MVT deposits; and (3) lead to a discussion of potential applications of this methodology to unravelling the significance of galena Pb-Pb arrays documented for several deposits in the Bathurst Mining Camp (BMC). Specifically, careful sampling to isolate relict galena in stockwork zones followed by trace-element mapping by LA-ICP-MS to reveal patterns of volatile-element zoning (e.g., Se, Tl, Cd, Sb). Complex primary zoning is well documented in pyrite in the BMC such that galena shielded from the effects of dynamic recrystallization may also preserve growth zoning. Zones of diagnostic metal abundances can then be targeted for in-situ Pb isotope measurements, allowing us to uniquely connect key metal associations with Pb reservoirs. Although significant deviation of isotope ratios for Pb sourced from magmatic versus volcano-sedimentary reservoirs may be small, it may still be possible to examine systematic shifts in Pb sources as a function of trace-element characteristics. Some deposits (Restigouche) have a higher proportion of Pb sourced from an older granulitic low-µ Avalonian basement. By comparison, upper crustal volcano-sedimentary successions have a more radiogenic time-integrated Pb isotope signature. Distinguishing the two endmembers is only possible using an in-situ approach using isotope and trace-element discrimination trends.

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