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Fast, high resolution mapping of fine-scale trace element distribution in pyrite and marcasite by LA-ICP-MS with the Aerosol Rapid Introduction System (ARIS)

Merilie A. Reynolds[1], Sarah A. Gleeson[2,3], Cora A. McKenna[4] and Balz S. Kamber[5]

[1] Department of Earth and Atmospheric Sciences, University of Alberta

[2] GFZ, German Research Centre for Geosciences

[3] Institute of Geological Sciences, Freie Universität Berlin

[4] Department of Geology, Trinity College Dublin

[5] School of Earth, Environmental and Biological Sciences, Queensland University of Technology

Summary

In economic geology, quadrupole (Q)-LA-ICP-MS has proven particularly useful in documenting the behavior of elements that rarely form their own minerals, instead substituting into the lattice of other sulfide minerals or siderophile elements in exsolved monosulfide solution minerals. Methodological improvements have permitted the use of increasingly small laser spot diameters but as the spatial resolution of the method continues to improve, increasingly complex internal element zonation has been revealed in many minerals. Two-dimensional semi-quantitative trace element maps are therefore increasingly used to provide a chemical context for later quantitative spot analysis. Although multi-element mapping by Q-LA-ICP-MS is rapidly advancing, there remains a fundamental compromise between spatial resolution, detection limit, and experiment duration. To address this limitation, we trialed the Aerosol Rapid Introduction System (ARIS) with novel operating conditions to perform fast, high resolution mapping of minor and trace element distribution in the minerals pyrite and marcasite. The ARIS is a high-speed transfer tubing system that can be fitted to existing Q-LA-ICP-MS to reduce aerosol washout times, permitting resolution of pulses at 40-60 Hz. In this study, ablation was conducted with a 5 µm beam aperture, a repetition rate to 50 Hz, and a continuous stage scan speed of 40 µm s^{-1}. The fast stage scan speed reduced the experiment time by 4-8 times compared to conventional mapping whereas the high repetition rate preserved the x resolution. The new method successfully mapped elements at single to double digit ppm levels and maps reveal fine-scale zoning of trace elements with an effective x and y resolution of 5 µm. Each mapping experiment removed ca. 1 µm of sample, preserving sufficient material for further analysis. Thus, ARIS-Q-LA-ICP-MS offers a fast, affordable, and minimally destructive method for mapping trace element distribution at high resolution in geological materials.