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Combining SEM-EDS and Micro-XRF-EDS Analysis: In-situ Search for Trace Mineral Phases in Meteorites

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Despite occurring in low abundances, accessory minerals in terrestrial and extraterrestrial rocks are key tracers of petrogenetic processes. Due to their typically small grain size the search for these minerals in large samples may be challenging. However, combining different analytical techniques yields a robust workflow that is time and resource efficient. Here, we present the advantages of integrating micro-X-ray fluorescence spectroscopy (micro-XRF) with Scanning Electron Microscopy (SEM) in the search for trace minerals in mesosiderites. Considered unusual amongst known meteorites, their composition includes metallic components originating from the core of molten planetoids, and silicates that may represent "crustal" remnants. Information on such samples can have a profound impact on our understanding of the processes of formation of our solar system and planet Earth.

Zircon grains are rare in mesosiderites but have been previously reported, for example, from the Vaca Muerta mesosiderite (1). However, searching for these trace minerals by traditional SEM techniques is time and resource intensive, with a requirement to identify grains and characterize their mineral associations. Compared with SEM, the high sensitivity for detection of trace elements by micro-XRF allows rapid scanning of large sample areas at spot sizes less than 30 µm, while the ability to detect higher energy X-ray lines minimizes peak overlaps that are common in the low energy portion of the X-ray spectrum. Furthermore, compositional information can be obtained from greater depth within the sample, accessing locations of additional grains not directly exposed on the surface. In this study Bruker's M4 TORNADO PLUS micro-XRF and XTRACE micro-XRF for SEM, both equipped with QUANTAX ESPRIT EDS, were employed. The approach allowed multiple rare phases to be identified from one rapid scan of complete samples, with mineral locations transferred to SEM for high resolution imaging of individual grains. Integrating both techniques reduced characterization time significantly, providing geochemical and mineral context to accessory phases in addition to high resolution grain information. While applied here to rare meteorites, this workflow has many advantages to the study of terrestrial materials.

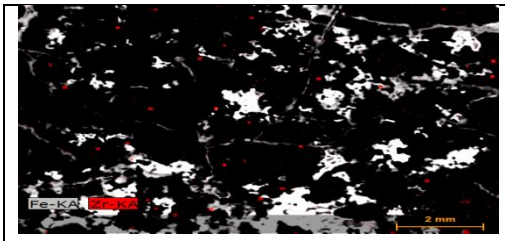

Figure 1. Element distribution map of Fe (grey) and Zr (red) in a Vaca Muerta meteorite collected using micro-XRF (M4 TORNADO PLUS). Knowing the location of zircon grains and other trace phases rich in Sr, Cr, Co and Pb from the micro-XRF map allows to rapidly target them with SEM-EDX and make use of its higher resolution analysis. Additional elemental information is simultaneously recorded during the scan providing full geochemical context for all minerals of interest. Scanned area = 100 mm².

References:

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