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## **'Trace-element-in-mineral' signatures: acquisition, interpretation and application**

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Whole-rock trace element data can often display distribution patterns of value for mineral exploration or in ore genesis studies. Potentially useful patterns are, however, susceptible to variation as a function of changing lithofacies and changing proportions of component minerals. In contrast to this, trace element analysis of specific minerals, each with a defined crystal structure and range of chemical composition, can be a powerful way to obtain robust, meaningful datasets. This is especially valid when that mineral is abundant in different rock types and sufficiently refractory such that signatures from individual stages in the ore-forming cycle are preserved (e.g. iron oxides; Keyser et al., this conference). Here we review recent progress and the future potential of 'trace-element-in-mineral' datasets. Examples are drawn from our current work on common sulphides and oxides, key accessory minerals (such as titanite and apatite), and on a range of rock-forming and mineralization-associated silicates (including feldspar and skarn garnet).

High-quality trace element data, with acceptable spatial resolution and sensitivity, can be readily obtained using laser-ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS), provided appropriate standards are available, and that the volume analysed in each point, line or 'mapped' area has been characterised petrographically prior to analysis. Interpretation and application of trace element data to problem-solving also requires a sound understanding of the geological context of each sample. Additional insight can be obtained from an understanding of the crystal structure of the phase analysed, particularly with respect to which elements are likely to be present, at what concentrations, by what kind of mechanism they are incorporated into the lattice, whether mineral nanoparticles are also present, and the likely trends of trace element partitioning among coexisting minerals (e.g. among base metal sulphides; George et al., this conference). We favour a holistic approach in which a programme of analysis covers most, if not all, minerals in a given assemblage, because the presence or absence of coexisting minerals will influence trace element concentrations. Understanding the geological history of a sample and, where possible, deriving independent constraints on conditions of formation or overprinting (e.g., crystallisation temperatures of feldspars; Kontonikas-Charos et al., this conference), can provide invaluable guidance in the correct interpretation of results.

Textural context is of critical importance and deserves appraisal by appropriate methods: SEM in BSE-mode, CL for transparent or semi-transparent minerals such as apatite (e.g. Krneta et al., this conference). Even 'clean-looking' grains of pyrite may retain evidence for three or more generations of growth. Furthermore, many mineral grains will be zoned at the micron-scale with respect to major and trace elements – including minerals such as galena conventionally thought of as being largely unzoned. Selection of analytical spots needs to reflect potential heterogeneity. Simple analysis of clean areas in the core of a grain will not necessarily deliver reliable, representative data. We demonstrate how trace elements can be concentrated along micro-fractures or boundary domains within grain aggregates. Where necessary, LA-ICP-MS data can be followed up by nanoscale investigation (e.g., Ciobanu et al.,

this conference), in which material is extracted in-situ by focussed ion beam-SEM methods, and a foil examined by transmission electron microscopy.

Trace element analysis by LA-ICP-MS requires careful consideration of which elements to analyse for, and the dwell times for specific elements. This information can often only be built up over successive analytical runs, and may vary from sample to sample. Surprises are always possible (e.g. Mo in garnet; Xu et al., this conference). Last but not least, the number of analyses per sample should be sufficient to derive good statistics, be fully representative of all textural and chemical heterogeneity, and be backed up by detail on the textural context of every analysed spot, line or mapped' area.

