Petrography at the age of mega-pixel XRF imaging

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Geological samples are extremely diverse and share a tendency for heterogeneity and complexity. This is especially true for ores, which result from complex processes in dynamic environments. In recent years, a number of tools allowing for imaging element distribution in geological samples at 1-50 μm-resolution and over mm^2 areas have seen rapid development and have become readily available. The application of synchrotron-based X-ray fluorescence mapping has been limited to addressing key questions because of low availability and high cost. However, recent advances in X-ray fluorescence detector technology are bringing new possibilities to petrology. Millisecond dwell times allow collection of thin-section size maps in hours, and improvement in data analysis produces quantitative elemental maps. The technique can be combined with XANES imaging to provide additional information about element speciation (e.g., As oxidation state).

We illustrate the applications of the technique for ore petrology (commodities: Au, Pt, U, Cu, Ge, Ti, REE, Nb) under a variety of geological contexts (sandstone-hosted U-deposit; hydrothermal PGE deposit; vein-type polymetallic hydrothermal deposit; IOCG; metamorphic REE-Nb-Ti). M(egapixel)-μXRF can efficiently provide the information necessary to understand element distribution in the context of thin-section scale textural complexity. Examples of outcomes include: (i) the distribution of μm-sized Pt-rich grains and Ti-mobility during schistosity formation at the Fifield Pt prospect (Australia); (ii) the presence of Ge associated with organic matter and of Hg minerals associated within zircon clasts in the Lake Frome U ores (Australia); (iii) confirmation of the two-stage Ge-enrichment in the Barrigão deposit, with demonstration of the presence of Ge in solid solution in the early chalcopyrite (Portugal); (iv) enrichment of U during late dissolution-reprecipitation reactions in the Cu-rich ores of the Moonta and Wallaroo IOCG deposits (Australia); (v) history of REE-Ti-Nb-(As) mobility during amphibolite to greenschift facies metamorphism in the Binntal Valley, Switzerland.