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LA-ICP-MS element mapping of pyrite and its applications

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Pyrite is a common mineral that efficiently incorporates metals during progressive precipitation and thus records the physiochemical evolution of fluids from which it was formed. It shows various textures and compositional zoning with variable origins. Due to rapid growth of element mapping techniques by LA-ICP-MS, detailed information on the behavior and paragenesis of trace elements during mineral crystallization and precipitation processes can be obtained. Element mapping can be performed using two different strategies. The conventional procedure is to acquire time-resolved signal intensity data during multiple, parallel, continuous line-ablations across a selected area. The quantitative element mapping technique uses "line of spots" sampling protocol so that it can generate spot-size-limited spatial resolution concentration maps. Due to different sampling protocol, the conventional technique can have element maps of signal intensity or qualitative concentration for selected minerals in a short time (generally less than 2 hours), whereas the quantitative procedure can have high-resolution and high-precision maps with much longer time (generally more than 6 hours). Thus, these two element mapping techniques can have different applications.

Quartz-carbonate lode-gold deposits define a very important type of gold deposit worldwide. It is characterized by quartz-dominant vein systems with minor (<5%) sulfide minerals (mainly pyrite and/or pyrrhotite). Pyrite can crystallize at different stages of gold mineralization. To reveal the history of gold mineralization, the quantitative LA-ICP-MS mapping technique has been applied to generate 2-D element concentration maps of pyrites from three gold deposits. Canadian Malartic is hosted by clastic metasedimentary rocks and porphyritic quartz monzodiorite and granodiorite. Textural evidence and elemental mapping have revealed five types of pyrite. The pre-mineralization py1 is likely diagenetic pyrite, with high Co, As, Se, and low Ni, Te, Sb, Bi, and Pb. Gold-bearing py2-py4 have covariant Co and Ni, high Au, Ag, Te, Bi, and Pb and generally contain abundant potassic components. Post-mineralization py5 has high Co and Ni and is poor in other elements. Pyrite chemistry thus supports a two-stage model comprising early syn-pyrite Au mineralization and a later post-pyrite upgrading. The Côté Gold deposit is hosted by the Chester intrusive complex. Nickel, As, Sb, and Pb generally increase from the core to the rim of pyrite grains, whereas Te and Ag have a reverse trend. Arsenopyrite grains have high Co, Ni, Se, Sb, and Te, but low Ag, Pb, and Bi. It is noted that Au is depleted in both sulfides, but is enriched in silicate minerals as nanoparticles, indicating that gold mineralization post-dated pyrite precipitation. The Musselwhite deposit is a BIF-hosted lode gold deposit. Diagenetic pyrite nodules from this deposit are enriched in Co, Cu, Ni, Se, As, Ag, Sb, Te, Au, Tl, Pb, and Bi. However, recrystallized pyrite and pyrrhotite are depleted in such elements, suggesting that some of the gold was released from auriferous pyrite to fluids via metamorphic recrystallization.