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Source of fluids in orogenic and intrusion-related gold deposits: insights from trace elements in pyrite

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A diverse range of gold mineralization has been observed in greenstone belts worldwide, spanning from synvolcanic to syntectonic deposits. Whereas most syntectonic deposits are considered orogenic in origin, formed by metamorphic fluids, the contribution of magmatic-hydrothermal fluids remains a debate. This study examines the trace element composition of over 1500 pyrite grains from 50 deposits within the Archean greenstone belt of Abitibi, Canada, using LA-ICP-MS. Our case studies are representative of various types of syntectonic mineralization, including 1) As-rich and As-poor orogenic deposits 2) intrusion-related deposits.

Using our novel multielement discrimination diagram, normalized to Archean sedimentary pyrite, we demonstrate that the variability in the trace element pattern of pyrite reflects the source of the ore-forming fluids. Pyrite from As-rich deposits (both sediment-hosted and volcanic-hosted) exhibit a flat signature, similar to Archean sedimentary pyrite, but with positive anomalies in Au-As-Sb-W. Compilation of pyrite from major As-rich gold districts worldwide, typically sediment-hosted have the same signature. In these cases, devolatilization of underlying sediments release Au-As-Sb from pyrite and W from rutile into the metamorphic fluids. The pyrite signature of these gold deposits thus reflects the composition of these fluids. In contrast, pyrite from As-poor orogenic deposits are depleted in most trace elements. This pattern is similar to pyrite from altered magmatic sulfide droplets in basaltic rocks. We propose that in this case, the source of the ore-forming fluids may result from the devolatilization of mafic crust. Finally, pyrite in intrusion-related deposits, associated with sanukitoid intrusions, display a flat to moderately depleted pattern with distinctive positive anomalies in Au-Te-Ag-W. This signature closely resembles that of modern alkalic porphyry deposits, where the magmatic contribution of gold and fluids has been irrevocably established. Detection of a magmatic input, using pyrite, could influence exploration strategies, early-on, for future gold deposit discoveries.