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From Economic Geology to Ocean Chemistry: The Wide Range of Information that can be obtained from a Humble Pyrite Grain

Pyrite incorporates a portion of the trace elements dissolved in the fluids from which it formed. Thus trace element analysis of pyrite grains can give us information of these past fluids with applications as varied as understanding changes in ocean chemistry to identifying ore deposit type. We have analysed over 1400 pyrite grains from sedimentary rocks through geologic time using laser ablation ICPMS. Periods in geologic time when several trace elements are enriched in pyrite match with times where whole rock analyses of redox sensitive trace elements also show enrichments. This suggests that pyrite chemistry, like these traditional whole rock studies, can be used to understand changes in ocean chemistry and the atmosphere through Earth history.

Pyrite also incorporates trace elements from hydrothermal fluids. Because pyrite forms in many different deposits and those deposits have different fluid compositions pyrite chemistry should be a viable way to identify ore deposit type. This is important as near surface deposits are increasingly exploited and new large deposits will be found at deeper and deeper depths. This requires deeper drilling and increased costs, thus we must get as much information from each drill hole as possible. If pyrite can be utilized to identify ore deposit type it will allow for application of geological models early in an exploration program enhancing efficiency of the drilling. In this study we present almost 4,000 LA-ICPMS trace element analyses of pyrite from 84 different deposits (including porphyry, hydrothermal breccia, IOCG, SEDEX, VHMS, orogenic gold, and skarn) and unmineralized sedimentary pyrite formations. These data are used to train a Random Forest data learning algorithm to identify ore deposit signatures based on the trace element composition of the pyrite associated with them. Results using the initial test data show promise with Random Forests correctly identifying the ore deposit type 80-98% of the time (82% for high sulfidation, 95% for IOCG, 80% for orogenic gold, 88% for porphyry, 92% for SEDEX, 98% for sedimentary pyrite, and 93% for VHMS).

Prof. Daniel Gregory's research focusses on in-situ analyses of various mineral phases in order to understand changes in fluid chemistry during mineral formation. The research outcomes have important applications to diverse fields that range from environmental chemistry, economic geology, to paleooceanography. Most of his work has focused on laser ablation ICPMS analysis of the mineral pyrite with lesser emphasis on magnetite, hematite, chlorite, and titanite.