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Evaluation of the Geologic Hydrogen Potential of the Serpentine Deposit, Duluth Complex, Minnesota, U.S.A.; Integrating Automated Mineralogy and Continuous XRF Core Scanning

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Abstract Text:
Natural hydrogen is expected to be the fuel of the future and to play a major role in the green energy transition. Hydrogen can be produced when ultramafic rocks interact with water through the process of serpentinization. During this mineralogy-controlled reaction, water is reduced to hydrogen gas, oxidizing ferrous iron in primary minerals to form ferric iron in secondary minerals. Recent studies have hypothesized that ultramafic rocks subjected to carbon sequestration or metalliferous ore mining may produce hydrogen following this pathway.

This study assesses the potential of ore-hosting ultramafic rocks in the Mesoproterozoic Duluth Complex of Minnesota to generate significant quantities of hydrogen. Exploration drill core from the Cu-Ni-(PGE) Serpentine deposit hosted by the South Kawishiwi intrusion was acquired, and downhole bulk chemistry data from nine drill holes was obtained using a Minalyzer continuous XRF core scanner. Light element detection improved by optimized instrumental configuration led to Mg detection limits of 0.08 wt.%..

Using MATLAB, the factory-calibrated major element (Si, Al, Fe, Mg, Ca, Na, K, Ti, and Mn) data was subjected to k-means cluster analysis, revealing three chemically distinct clusters. Fifty-two representative sub-samples were collected, including those with the highest and lowest concentrations of each major element, with high amounts of Cu and Ni, and with chemistry closest to each cluster mean. Whole-rock geochemistry from sixteen of the sub-samples allowed for matrix-matched calibration of the dataset. Automated mineralogy data will be collected for all sub-samples and used as a training dataset for a newly developed MATLAB-based machine-learning program to accurately assess lithology down hole based on continuous XRF core scanning data.

This method has applications in further hydrogen exploratory work, as well as in other fields of mineral exploration which could benefit from automated methods of constructing deposit-scale lithology models, especially when multiple Fe-bearing minerals are involved. Preliminary data screening has identified intervals containing up to 16.78 wt.% Fe, which could react to form 0.30 wt.% H_2; characterizing mineral assemblages will constrain iron valency and refine the resource model.

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