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HYDROGEOCHEMICAL PROSPECTS FOR MINERAL EXPLORATION - PHASE 1

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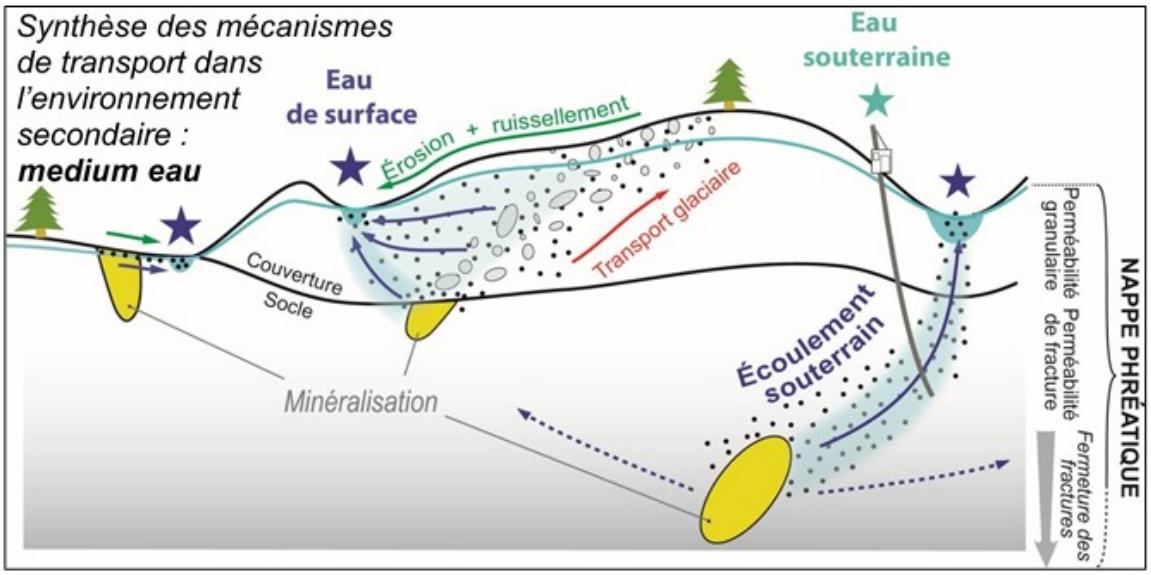
DETAIL

The detection of superficial secondary footprints is an effective and essential tool in the search for mineralization in bedrock. This project had the mandate to evaluate the prospects of using natural water hydrogeochemistry for mineral exploration. More specifically, it aims to investigate the geochemical footprint of mineralization of surface waters found on bedrock substrate; this constitutes the both the hydrographic network (lakes, streams) and groundwater in the confined and unconfined aquifers. These exploration tools have several major advantages including their low cost and ease of sampling. In addition, these methods fall within the realm of deep exploration, as the aquifers present the footprint of buried metals found up to several hundreds of meters below the surface.

In a first stage, three case studies from the literature were presented, offering examples of local surveys of hydrogeochemical footprints from known deposits: 1) the VMS Zn-Pb-Ag outcrop of Red Mountain, Alaska; 2) the VMS Cu-Pb-Zn of the Archean Yava in the Hackett River Belt, NWT, buried under 20 m of glacial till; 3) the giant Cu-Au-Mo porphyry of Pebble, Alaska, partially buried under several hundreds of metres of post-mineralization volcanites. In the three cases, the presence of the deposits was detected by very clear anomalies in metals within the downstream hydrographic networks.

A large database of ICP analyses of surface waters was compiled from 24 regional surveys carried out by the OGS across several greenstone belts in Ontario, for a total area of 88 580 km^2. A multivariate statistical treatment applied to 24 500 analyzes, converted to local percentiles, identified the factors controlling the base levels for several elements of interest in the goal, in a second stage, of developing a tool for the enhancement of the “real” anomalies that are unrelated to normal background variability. Baseline geochemical levels showed significant variability and formed several hydrogeochemical areas essentially correlated to bedrock geochemistry (32 to 42 % of the variance) and anthropogenic effects (salting of roads, 14 to 17 % of the variance). More specifically, the primary controlling factor, by far the most dominant, is the ability of basement rocks to buffer the pH of water. It represents a very clear proxy of bedrock geology, with the pH surface waters higher overall over the greenstone belts and the alkaline intrusions than over the gneissic provinces, higher over felsic post-tectonic intrusions than over the foliated TTG series or gneissic rocks. A very clear correlation is highlighted between areas of regional hydrothermalism (along the first order faults) and alkaline-trending surface waters, due to the buffer of hydrothermal CO_2 on pH. These regional variations of pH induce background variations for several items of interest (Zn, Cu, Au, etc.) so that bulk gross concentrations do not reflect the concentrations of the underlying basement: the effectiveness of this technique for identifying metal concentrations for the exploration of metals, before any treatments, is therefore mixed. The use of these data implies, therefore, for anomalies to be enhanced by correcting for variations in the base levels. Several methods for enhancement were tested; the most efficient proved to be a standardization by Al. Al shows no statistical correlation with the known mineralizations, however forms, in contrast, regional areas of comparison to those of Zn and Cu in a first approximation (1st factor at least), so that the Zn/Al and Cu/Al ratios cancel out variations related to these domains. Thus, this demonstrates that these ratios are good proxies for the base concentrations in Zn and Cu and are good markers of mineralization with a proven effectiveness on the known deposits (rate of anomaly between 1 and 2 km of the deposit, two times higher than normal).



SUMMARY SHEET

Objectives	• Evaluate the performance of hydrogeochemical surveys of natural waters for the mineral exploration. • Document case studies from different depositional contexts. • Propose sampling protocols. • Develop analytical methods for surveys and the enhancement of anomalies.
Results	• Compilation of case studies published in the literature for buried, slightly buried, and exposed mineralization: in all cases, the performance of surface waters for the detecting deposits was superior to other substrates (lake sediment and creeks). • Compilation of a large surface water database produced by the OGS since 1995: 37 980 water samples, mostly analyzed by ICP-MS, distributed across 24 regional surveys that cover 88 580 km^2. • Multivariate statistical analysis of the background noise and anomalies of the database: 1) Dominant control of background noise by the geochemistry of the bedrock (ability to buffer pH) and anthropogenic effects (salting of roads) → very marked hydrogeochemical areas. 2) Performance tests of known (Zn, Cu) deposits: "true" anomalies (i.e., related to mineralization) are much enhanced when normalized to Al → Zn/Al, Cu/Al are powerful proxies for the estimation of Zn and Cu concentrations in bedrock at the regional scale. • Groundwater: insufficient data, and a need for new surveys to acquire/compile data. • In-depth discussion of sampling protocols (literature review).
Innovations	• Identification of hydrogeochemical domains for surface waters associated with significant overall variation from baseline. • Demonstration of the performance of Zn/Al and Cu/Al ratios for the enhancing "true" anomalies.