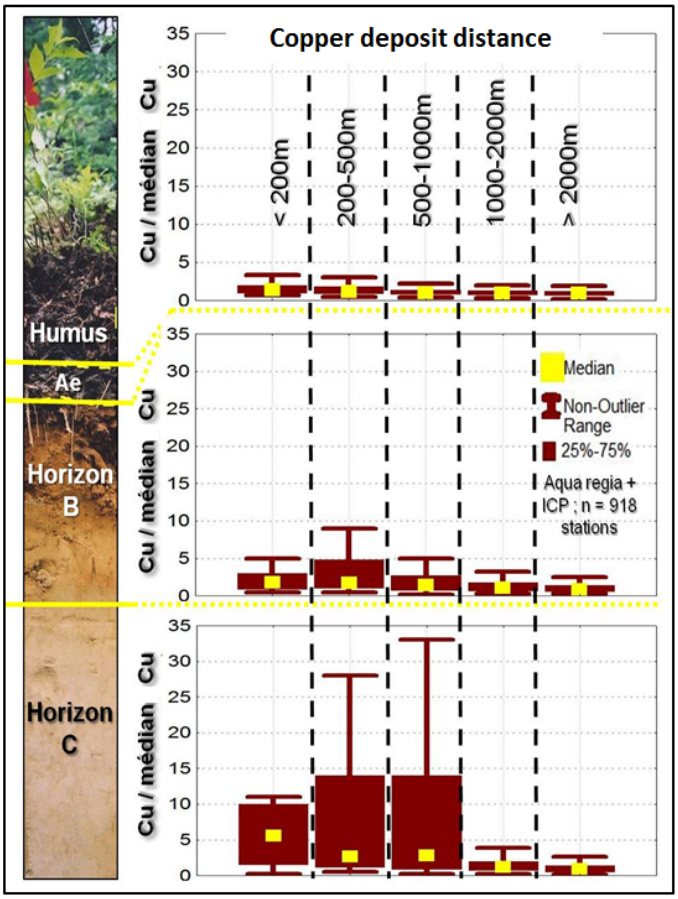
Project 2011-06: Optimisation of soil geochemical data using strong acids

The project was designed to verify the effectiveness of using soil geochemistry in mineral exploration, and to propose quantitative and qualitative ways of optimisation. The optimisation is divided into three levels corresponding to the three stages of a soil geochemical survey: 1. Sampling (choice of suitable soil horizon depending on the targeted signature, and the environmental, geological and pedological context), 2. Laboratory (choice of extraction and measurement methods depending on the sampled horizon and the targeted signature), 3. Processing (enhancement of anomalies and normalisation of background noise). This division gave a solid foundation to the research project. The points mentioned for the three stages were addressed either individually or collectively.

Soils are a very complex, sensitive and reactive environment. Effective use of soils in exploration requires some basic knowledge of the physico-chemical processes in action. Particular attention was paid to the following points: behaviour of metals during pedogenesis (metal segregation); specific concentration profiles for Ni, Cu, Pb, Zn and Au; differentiating primary and secondary metals (secondary metals are the ones released during the destruction of labile sulphides, transported by hydromorphism and fixed in receptive soil horizons) and the extraction methods for removing them from the different soil horizons: humus-Ah, B, C. A more quantitative second step tackled the following questions for each element: 1) nature of the metal signature in the various differentiated horizons (soil enrichment of the signature dependent or independent of the mineralisation present, height of the base and the anomalies), 2) the horizon with the greatest anomaly restitution potential originating from a nearby deposit.



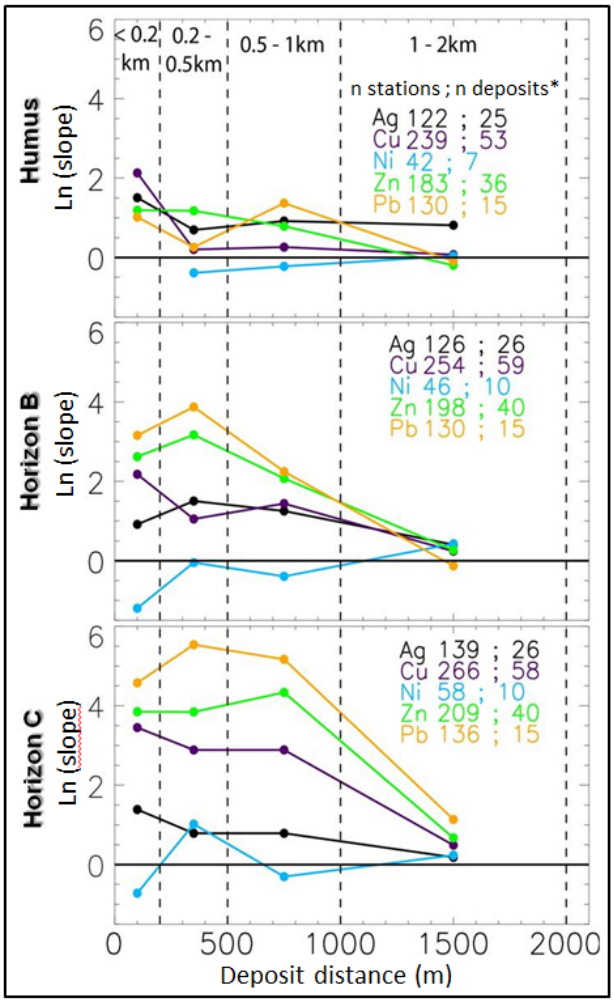
Amplification profile of copper content in soils near copper deposits (data from 918 stations and 90 deposits)

Answers to these questions can be found through a statistical analysis of several existing regional surveys (OGS) containing multi-horizon sampling stations (humus, B, C). In total, 2 900 stations were compiled from a total of 8 surveys. We show that Pb, Zn and Au have a systematically high base level in the organic horizon (humus-Ah), suggesting that these elements have a marked affinity for organic matter, whereas Cu and Ni are more concentrated in C horizon (profile dominated by leaching). However, the high Pb, Zn and Au signature in the humus correlates very poorly with mineralisation: it is a variable signature, extremely sensitive to air pollution (foundries, roads…) and to weather conditions. The use of this horizon for exploration is not recommended. For all elements under consideration, C horizon systematically shows the best enrichment associated with mineralisation (attached Figure).

The performance of the three horizons is statistically quantified by the « slope » parameter, the ratio of the probability of anomalies between a population *X* (for example < 1 km from the deposit) and the total population (Bonham-Carter, 1994). This parameter is a standard, objective and reliable indicator of performance. A comparison of the humus, B and C horizon slopes at different distances from the deposits shows that (attached Figure):

1. C horizon has the best potential for detecting deposits, followed by B horizon, whereas the humus is very inefficient;
2. anomalies associated with deposits are detectable in the C horizon at distances of < 1 km;
3. gold analyses in the three horizons show very poor ability for detecting gold deposits, in contrast with a relatively good performance by arsenic in the C horizon for samples taken more than 1 km from the deposits.

An enhancement method is proposed for base metals. It is based on processing the metal background noise associated with the presence of phyllosilicates. The effectiveness of this method is shown by an almost systematic increase of the slopes in B and C horizons.



Values showing the performance of humus, B and C horizons in detecting Ag, Cu, Ni, Zn and Pb deposits

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Project 2011-06: Summary	
Objectives	• To optimise soil geochemical methods for mineral exploration.
Results	• Advanced documentation about metals during pedogenesis, profile-types for Cu, Ni, Pb, Zn and Au concentrations in the differentiated soil horizons. • Humus: Pb, Zn and Au base levels are elevated, but very low correlation with mineralisation, very variable signatures, significantly affected by weather conditions → not recommended in exploration. • C horizon: Cu and Ni base levels are high, very good statistical performance for all base metal exploration → preferred horizon for exploration. • B and C horizons: well correlated signals (base levels and anomalies). • An innovative approach is proposed for augmenting effective anomalies for base metals. • Au: poor performance in all horizons; arsenic is more efficient.
Innovations	• New light on the performance of a variety of methods. • Enhancement method for base metals.