# Spectral induced polarization on roll-front type deposits

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Uranium exploration in roll-fronts type deposits is a major issue for mining companies. Indeed, these geological objects are currently exploited at very low production costs.

Roll-front deposits consist of interbedded sequences of permeable and impermeable layers. Uranium mineralization occurs at redox interfaces generated by oxidising groundwater flow in permeable layers. Reduced part is mainly associated with disseminated and low-grade Fe-sulphides (pyrite) while Fe-oxide minerals (hematite, goethite) mark oxidised part. Some high-grade (%) of pyrite can be observed at redox boundaries.

Currently, ore delineation is carried out by successively drilling reduced part (hydrological down-gradient side) then oxidised part (up-gradient side). Aim of this study is to assess the suitability of Spectral Induced Polarization in order to optimize drill hole implementation. Nevertheless, characterization of roll-fronts by geophysical ground survey is challenging due notably to the aquifer high conductivity, clay bed, low-grade mineralization and depth.

Due to the ability of Spectral Induced Polarization (SIP) in providing information about rock mineral composition and notably to detect tenuous signal of metallic particles polarization, SIP was assessed on synthetic samples in laboratory and was implemented on Areva Mongolian permit.

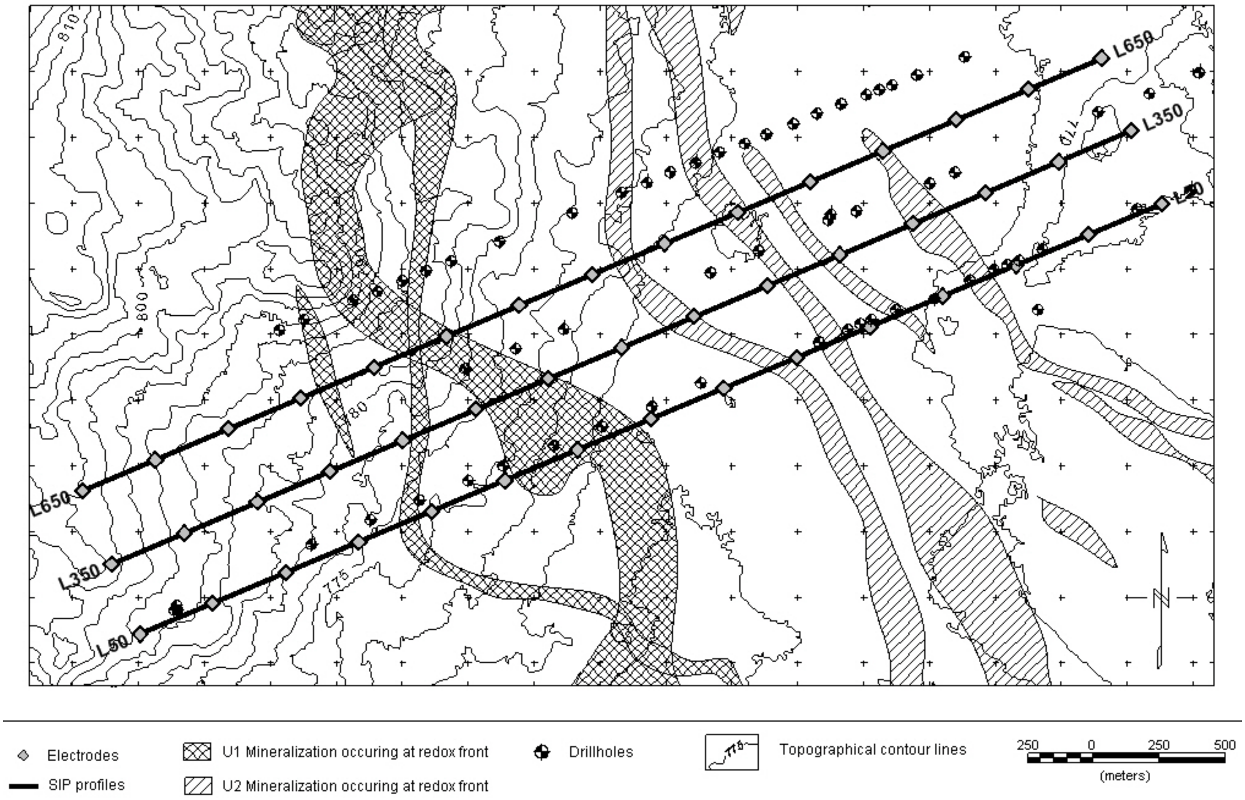


*Fig. 1: SIP profiles implementation according roll-front mineralization.*

To assess the feasibility of SIP, measurements were carried out on synthetic samples setting up with main characteristics of studied Mongolian roll-front. Indeed, sulphur and hematite dissemination represent only 4.8 ‰ of mineral fraction. Permeable layers are mainly composed by unconsolidated sandstone. This study took also into account the aquifer high conductivity. Samples were saturated with conductive solution of 2.18 mS $cm^{-1}$ composed by main ionic element of Mongolian aquifer. Main results of this laboratory study demonstrated that adding pyrite and hematite led to a resistivity decrease of amplitude spectra. But only adding pyrite influenced the phase spectra between 5 Hz and 1 kHz. That is to say that, on field involving 4.8 ‰ disseminated minerals, identification of oxidised from reduced area could only be done by pyritic signature. At this stage of this study, we expected a lateral variation of phase shift between reduced and oxidised areas.

SIP method was implemented on a Mongolian roll-front in 2012. Two units are notably investigated and are located between 200 and 350 meters depth. Three parallel profiles of 4.2 km length and separated by 300 m were set up (Fig. 1). The profiles orientation was perpendicular to roll-front deposits. Electrodes spacing was 300 m, with 15 electrodes per line. The equipment used for this acquisition was a GDP $32^{II}$, as receiver, and GGT-10, as transmitter, from Zonge International. Spectra were acquired from 0.125 Hz to 72 Hz.

Due to the high conductivity of this environment, large electromagnetic coupling is expecting. To interpret the data, three approaches were evaluated to isolate this phenomenon.

First one consists to simply use a 3-point decoupling phase (known also as "Coggon phase", Coggon 1984) based on a power-series representation of the phase spectrum using information at three frequencies. Nevertheless, we demonstrate that the use of this method do not comply with its application limits in our geological context.

Second approach consists in treating SIP method as an EM method by calculating mutual impedance between cables based on a complex resistivity distribution. To achieve this goal, we invert SIP data with Cr1DInv developed by Ghorbani et al. (2009). In our context, results showed that increasing depth of investigation is associated with decrease of problem resolution.

Final approach consists in decomposing ground IP response and EM coupling response in two Cole-Cole dispersion terms. Amplitude spectra at lowest frequency and drill hole logging allowed us to establish a first approximation of ground DC resistivity. To obtain estimates and uncertainty of Cole-Cole parameters, we invert SIP data using Markov-chain Monte Carlo based stochastic algorithm developed by Chen et al. (2008). Results showed that Cole-Cole dispersion terms attributed to EM coupling are well determined but low chargeability of the ground leads to large uncertainty concerning Cole-Cole dispersion terms related to ground IP effects.

In perspective of this study, a sampling survey was undertaken in order to integrate dispersion terms obtained on "real" rock samples. We expect to better constrain initial model and reduce uncertainty related to low chargeability of the ground.

**References**

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