# APPLICATION OF ELECTROMAGNETIC TRANSIENT METHOD FOR Zn-Pb EXPLORATION AT THE CHO DIEN – CHO DON DISTRICT, BAC CAN PROVINCE, NORTH VIETNAM

Chau NGUYEN DINH[1], Wojciech KLITYŃSKI[1], Szymon ORYŃSKI[2], Phu PHAM NGUYEN[3]

[1]*AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, al. Mickiewicza 30, 30-059 Krakow, Poland, cnd@agh.edu.pl*
[2]*Institute of Geophysics, Polish Academy of Sciences, ul. Ks. Janusza 64, 01-452 Warsaw, Poland, sorynski@igf.edu.pl*
[3]*Institute of Geology and Mineral Resources, Scientific- Research Institute, Chien Thang 79, Hanoi, Vietnam*

## Introduction

The zinc-lead Cho Don – Cho Dien deposit in Bac Can province North Vietnam belongs to the greatest Zn-Pb deposits in this country. Its area amounts to 40 square km, the Zn-Pb bodies have a few to several tens meters of thick and several tens to hundreds meters of length trending NE-SW direction and dipping under 30° to 60°. The ore bodies are hosted in the limestone and limestone-sandstone suits (Fig.1).
The morphology of the studied area is very rough, there is more than 200 m of relative height and there is an area of the dense jungle. All mentioned conditions make many difficulties for geological and geophysical works survey. The resistivity of Zn-Pb ore bodies and host rocks ranges from tens to hundreds Ωm and a few hundreds to thousands Ωm respectively (Tang et al., 2015).
The authors attempted to appraise the effectiveness of the proposal transient electromagnetic method (TEM) based on the results of the modeling processes. The parameters of the modeling are resistivity of considered medium, current power, geometry and frequency of transmitting system and level of noise.
The TEM has been used in mineral exploration for many years (Spies, 1980). Its effectiveness is very high in the geological conditions, where there is a contrast between good conductive ore zones and poor conductive surrounding medium. TEM system works in time domain where the inductive electromagnetic field from the ground response to a pulse current 'I' with specific frequency is investigated. Alternating current in an ungrounded transmitting loop (usually in the form of a square with size '**L**') on the surface is a source of a primary electromagnetic field. It induces eddy current in the ground and transient decay of a secondary electromagnetic field, which is recorded by receiver coil placed within the transmitting loop on the earth surface in the time interval between the pulses.
The voltage decay [nV/m$^2$] measured by the receiver coil reflecting the induced electric fields depends on the conductivity, depth, shape and size of the ore body as well as on the conductivity contrast to the surrounding medium (Klityński et al., 2014).

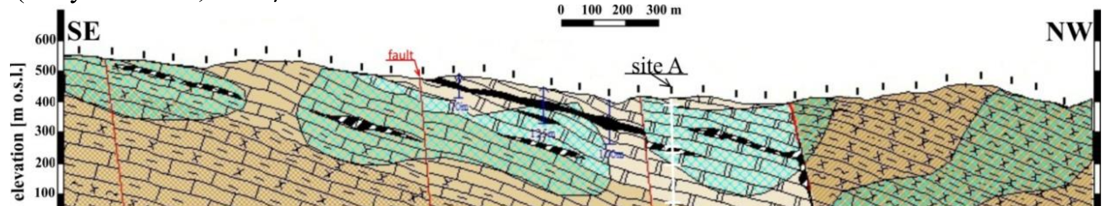


***Figure 1**. Geological cross-section.*

As we know inductive (measured) potential reflects distribution of resistivity in the ground and it decreases more slowly in good conductive medium than in poor conductive one (Keller, 1997). In our case the good conductive Zn-Pb ore bodies are surrounded by very high resistivity limestone suggesting us to consider possibility of TEM method in several aspects of large loops with sides '**L**' 100 to 400 m and high current '**I**' from 1 to 5 A. The proposal parameters of the transient loop are necessary to obtain appropriate depth of ores body and vertical resolution for the studied geology (Fig.1).

## Samples and methods

Generally the depth of investigation and resolution depend on the loop size "**L**", power '**I**' and the interval time ($t^*$ - $t_{max}$) within which the decay voltage is decaying at the rate $t^{-5/2}$. According with Spies (1989) the average noise level is 0.5 $nV/m^2$, this value determines the threshold of measured voltage and the maximum time thereby. The synthetic data are calculated for the 1D geoelectric model corresponding to the geology at site A (Fig. 1). In our modeling the assumed frequencies of the AC source current are 500, 100, 50 and 25 Hz, so the correspond interval time is from about 4.5 μs to 7.1 ms and loop sizes 100 m and 400 m.

To appraise the effectiveness of a proposal model in the TEM the calculated signal from the model is compared with the signal from the half space built of the poor conductive material. In our case the layer model is a high conductivity ore zone (Pb-Zn) in low conductivity surrounding (limestone).

## Results

Fig 2A and 2D are showing the variation of the received voltages for the layer model and half space using the loop size **L** =100 and 400 m respectively. The received voltage in the time of 0.1–1 ms (within the circles - Fig. 2A and 2D) for the layer model is significantly higher than that for the half-space for both mentioned loop sizes. The dependences of the calculated apparent resistivity are presented in the Fig. 2B and Fig. 2E, both the figures showing a minimum resistivity in the time of 0.1 – 1 ms. The interpreted resistivity with depth well enough correspond to the layered model (Fig. 2C and 2F).

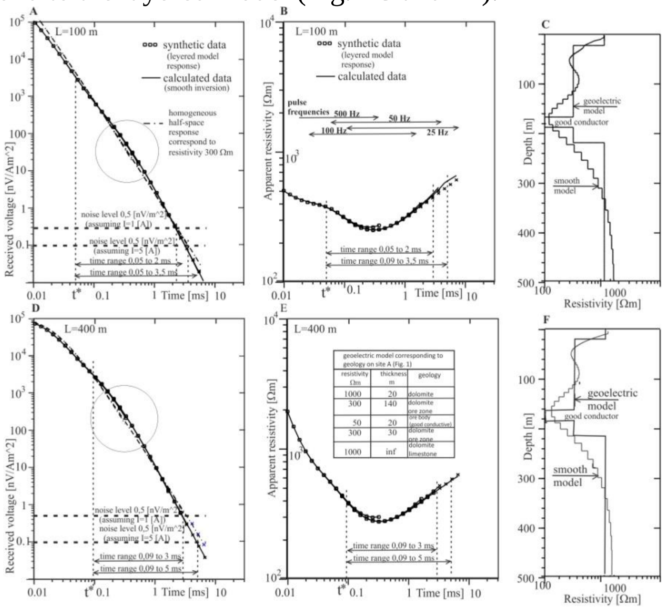


***Figure 2.*** *Synthetic TEM received voltage, calculated apparent resistivity and resulted smooth geoelectric model corresponding to the geology cross-section at the site A (Fig. 1) for **L**=100 m – Fig. 2A, 2B, 2C and for **L** =400 m Fig. 2D, 2E and 2F*

## Conclusions

The TEM technical method with the loop size **L** = 100m and 400 m, power alternating current from 1 to 5 Amperes and recording time of about 0.01 to 10 ms can be used with satisfaction effectiveness for the studied deposit.

## Acknowledgment

Paper was financially supported from the research subsidy nr. 16.16.140.315 at the Faculty of Geology Geophysics and Environmental Protection of the AGH University of Science and Technology, Krakow, Poland, 2019.

## References

Keller G. V., 1997. Principles of time domain electromagnetic (TDEM) sounding. The Leading Edge, 16: 355-357.
Klityński W., Stefaniuk M., Miecznik J., 2014. Time-domain electromagnetic method in geological research. Annales Societatis Geologorum Poloniae, 84: 71-79.
Spies B. R., 1980. The application of the transient electromagnetic method in Australian conditions : field examples and model studies. Macquarie University, [Sydney]: 153-164.
Spies B. R., 1989. Depth of investigation in electromagnetic sounding methods. *Geophysics*, 54: 872-888.
Tang, D., N., et al., 2015 – Report about the geological and geophysical works for prospecting of Pb-Zn at Cho Don – Cho Dien, province Bac Can, North Vietnam. (in Vietnamese).