Concept of our New Multi-Channel SIP Instrument - SIP256D -

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4th International Workshop on IP, June 6-8, 2016, Aarhus, Denmark

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INTRODUCTION

In the last few years, the number of possible applications of the method of spectral induced polarisation (SIP) has had a notable sharp increase. An example of one such application is the determination of the coefficient of permeability of sand and sandstone, which is important for hydrogeologists (Weller et al, 2010). The assessment of the health of a tree through characteristic features in the impedance spectrum should also be mentioned (Martin et al., 2013). The basis for this was in-depth knowledge gained in the laboratory in the last few years about the connection between petrophysical attributes such as pore space geometry, pore fluid conductivity (Hoerdt et al, 2014) and temperature (Bairlein et al, 2014) of non-mineralised rocks and their resulting frequency dependent electrical impedance. The size of the formation is closely linked with the frequency, at which it is represented in the spectrum. This means that impedance measuring devices must be able to deliver a high quality of data in a wide frequency range. For example, our Chameleon instrument (Radic, 2014) gives measurements between 0.001 Hz and 250.000 Hz - 8^{1/2} decades.

THE NEW INSTRUMENT - SIP256D

We have now developed and for the first time shipped the successor, the "SIP256D". An important new feature is the extension of the frequency range to 20 kHz. There are several options necessary and available in order to lower possible capacitive coupling effects. The most effective option is the relocation of the transmitter from the beginning of the profile to the current electrodes (Figures 3 & 4). Thanks to the conceptual flexibility of the instrument, the technical effort can be adjusted in a way to fit the actual requirements. Active shielded current cables (Figure 5) are enough for impedance measurements with frequencies up to 1 kHz. The potential lines can also be run separately. In order to have more measuring channels, each Remote Unit can also be equipped with 8 channels for the voltage measurements (Figure 6). The respective potential electrodes can be placed parallel, orthogonal or vertical (drill hole). By doing so, the measurement progress is not reduced. For large configurations, the signal voltages become typically very low. Switching the amplification reduces the instrument noise by a factor of 25. This increases the signal to noise ratio in remote areas with typically low artifical noise. But also in dense populated areas if the reference technique is used.

THE CHALLENGE

In order to be able to widely use the knowledge gained in the laboratory also in the field, the range of measurement has to be increased to include higher frequencies. Measuring devices for use in the field have to, however, meet further requirements. In this way, a higher progress in measurement and a higher degree of automation are expected of a modern measuring instrument. For geoelectric direct current measurements the concept of a multi-channel multi-electrodes instrument has established itself. (Figure 1). This concept has, however, for IP measurements limited suitability. Measurement results are already systematically and irreversibly biased at frequencies from ~10 Hz. An analysis of this concept shows that the cause of this is not the electronics themselves, but is the cable, which connects the electrodes with the electronics. (Dahlin, 2012). There is a multitude of coupling effects because of the capacity of the cable. These increasingly bias the impedance measurements with a higher frequency.





Figure 3: SIP256D with built-in transmitter.



Figure 1. Schema of a typical multi-electrode instrument for geoelectric measurements. The electronics for voltage and current measurements are located together with the transmitter in one casing. A multicore cable is used to connect the electrodes (*P*, *C*) with the electronics. Typical cable lengths are tens up to hundreds of meters. Capacitive coupling between the cables and the soil results in systematic data errors.

MULTI REMOTE UNIT CONCEPT

In 2005 we presented a measuring instrument (SIP256C) which is conceptualised in completely new way. Potential cables, which run parallel to the current cables over long distances, can be avoid because a data logger (Remote Unit) is placed at each electrode (Figure 2). Current and voltage measurements take place directly at the electrodes. Therefore, coupling effects are significantly lowered. In doing so, spectral resistance measurements up to 1 kHz are made possible.



Figure 4: SIP256D with mobile transmitter.



Figure 5: SIP256D with "active shielded" current cables.



Figure 6: SIP256D with 8 voltage measuring channels per Remote Unit.

Figure 2. Schema of our Multi Remote Unit instrument "SIP256C".

REFERENCESA

BAIRLEIN K., HOERDT A., BUECKER M. & NORDSIEK S. (2014): Experimental and theoretical studies of the temperature dependence of the spectral induced polarization (SIP) based on a membrane polarization model: Ext. Abstract, 3rd International Workshop on IP, Oleron Island, France, 6-9 April 2014.

DAHLIN T. & LEROUX V. (2012): Improvement in time-domain induced polarization data quality with multi-electrode systems by separating current and potential cables: Near Surface Geophysics, 2012, 10, 545-565.

HOERDT A. & BUECKER M. (2014): The salinity dependence of SIP parameters studied with an extended model of membrane Polarization: Ext. Abstract, 3rd International Workshop on IP, Oleron Island, France, 6-9 April 2014.

REFERENCES B

MARTIN T. & GUENTHER Th. (2013): Complex Resistivity Tomography (CRT) for fungus detection on standing oak trees: European Journal of Forest Research (2013) 132 (5-6), 765-776.

RADIC T. & KLITZSCH N. (2012): Compensation Technique to Minimize Capacitive Cable Coupling Effects in Multi-Channel IP Systems: Ext. Abstract, P81, Near Surface Geoscience 2012 - 18th European Meeting of Environmental and Engineering Geophysics, Paris, France, 3-5 September 2012.

RADIC T. (2014): Measuring IP Effects at high frequencies. First lab and field data from 0.001 Hz - 250 kHz: Ext. Abstract, 3rd International Workshop on IP, Oleron Island, France, 6-9 April 2014.

WELLER A., NORDSIEK S. & DEBSCHÜTZ W. (2010): Estimating permeability of sandstone samples by nuclear magnetic resonance and spectral-induced polarization: Geophysics 75, 215-226.

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