Preliminary results from a experiment to analyze stray current propagating along different soil strata

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Abstract: Earlier research documented the presence of magnetotelluric anomalies propagating stray current along conductive strata in the soil, but failed to pinpoint the origin of the AC ELF magnetic field encountered at the ground surface in rural environment. Current research aims to measure and analyze the stray current propagated in different conductive layers down to a depth of 18 meters. .

Keywords: Stray Current, Magnetotelluric Anomaly, Magnetic Field Survey, Electrical Infrastructure.

I. Introduction

In earlier research we have proved the existence of magnetotelluric anomalies propagating stray current with exogenous origin in relation to the specific farm under investigation 1 and furthermore documented various magnetic disturbances along such magnetotelluric anomalies 2. Concurrently we encountered low frequency magnetic fields of very high intensities (135,4 µT), but no corresponding AC current of similar frequency spectrum (ibid). It was hypothesized the the AC current responsible for the measured AC magnetic field was conducted in soil stratas of considerable larger depth than the ground rods utilized for the measurement was able to penetrate. We therefore devised a measuring probe enabling both measurement and spectrum analysis of stray current propagated along different soil strata. To the best of the authors knowledge, this is the first published attempt at analyzing the characteristics of stray current in different strata.

It should be noted that both the DC-based and AC-based stray current investigated in this analysis is exogenous [1], [3] to the farm where the measurement station is localized.

II. Literature Survey

It has not been possible to locate research papers regarding analysis of stray current in different strata of soil.

There mere concept of analyzing stray current is, however, well established, as ground based DC currents may enlarge corrosion problems in pipelines [4], [5] and stray current from HVDC powerlines has been extensively researched by the Swedish Radiation Protection Authority as the corrosive effects of this stray current may affect the containment of radiative waste [6], [7], [8]

The presence of DC-based stray current originating from man-made sources is therefore well established in the literature, although research into the specific characteristics of the spectral composition of the stray current propagated along each conductive strata until now has been largely unexplored.

III. Problem Definition

The purpose of this study is a preliminary analysis of the results from measurement and spectrum analysis of stray current propagated along different soil strata down to a depth of 18 meters.

IV. Methodology

A. Probe construction

A measuring probe was constructed from insulated copper cable type RKUB terminated in 50cm lengths of copper bar by soldering and applying heat shrink. One length of copper bar was placed for each meter and the different lengths of cable was strapped together with cable ties.

B. Placement of probe

A suitable magnetotelluric anomaly was located by the magnetic survey method described earlier [1].

C. Probe installation

Utilizing a number of 1 1/2" galvanized pipes, a water pump capable of delivering a flow of 1 m^3 pr minute at a pressure of 8 bar, the galvanized pipe was installed in the ground using a backhoe to provide steerage as the 3m lengths of pipe was blasted into the ground by water pressure. After reaching a depth of 18 meters the measurement probe was installed inside the pipes and the pipes were withdrawn using the backhoe, while the measurement probe remained in situ.

D. Neutral reference ground

For measurement purposes a reference ground rod was inserted into the ground at a depth of 18 meters yielding a measured resistance between ground rod and surrounding soil lower than 2 Ohm.

V. Results & Discussion

A. DC Current

The measurements indicate that a larger proportion of the DC-based stray current propagates along conductive strata in considerable depth.

Using an automatic curve fit yields an exponential function with a Pearsons R2 at 0,69, indicating a larger current flow in yet deeper currently unexplored depths. Some caution should be observed, however, as the signal to noise ration is unknown. The seemingly quite robust correlation might therefore result from a simple statistical fluke.

It should furthermore be noted that the stray current is measured against a long earth rod placed in neutral earth. This ground rod is fully conducting along its whole surface, which means that the measured current not only indicate the current propagated along a specific layer, but also any current traveling from the probe at the measured depth to any point on the reference electrode.

For measurement purposes the neutral reference electrode is throughout all measurements connected to the negative terminal on the scope. Data does therefore indicate an electron gradient from any depth at the measurement location towards the reference electrode.

The measurements strongly indicate that using only electrode arrays on the surface in order to survey or otherwise characterize stray current in open terrain is unsuitable as a tool for establishing full knowledge of any stray current present at the chosen location.

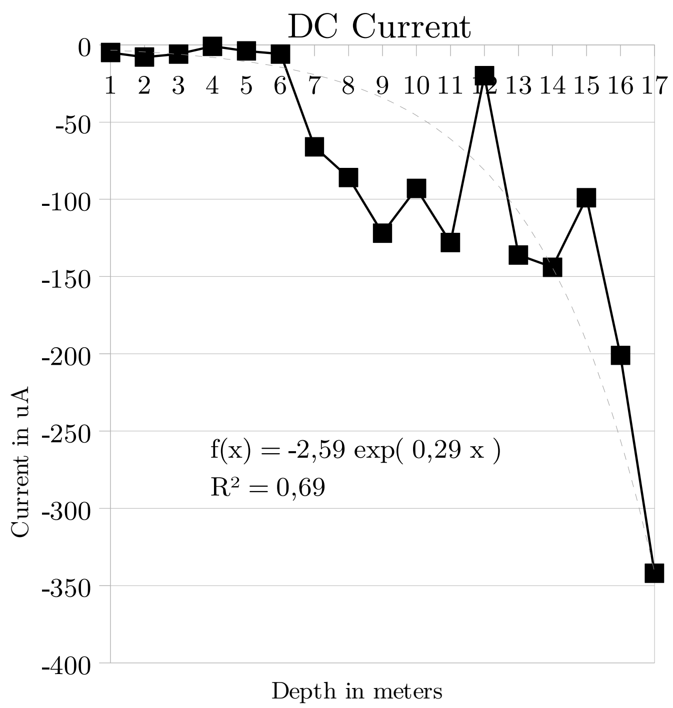

Figure 1: DC current measured at indicated depth against a reference electrode of similar depth in neutral earth. Negative terminal on the scope is connected to the reference electrode, indicating an electron gradient from the measurement probe towards the reference probe

B. AC Current

Measurement of AC current yields results quite similar to those presented for DC current, although the measured values are somewhat lower.

Best curve fit is an exponential function, with Pearsons R indicating a quite robust correlation at 0,75. However, the same caution as mentioned for the DC current applies here. We have no prior knowledge of natural variation of current at different depths, yielding the possibility that the seemingly interesting correlation could be explained by as a simple statistical fluke.

It is interesting, though, that measurements at the surface indicate nearly absence of AC current, while magnetometer readings clearly shows the presence of quite strong magnetic fields.

The measured values for AC current cannot, by themselves, explain the significant magnetometer readings published in earlier research [1], but as the exact current path is unknown, the exact amount of current actually carried in the conductive strata at 17 meters depth remains largely unknown.

The present measurement setup does not permit measurements of the electron gradient for AC current; but with further development with regards to technical measurement setup it should be possible to measure that component too.

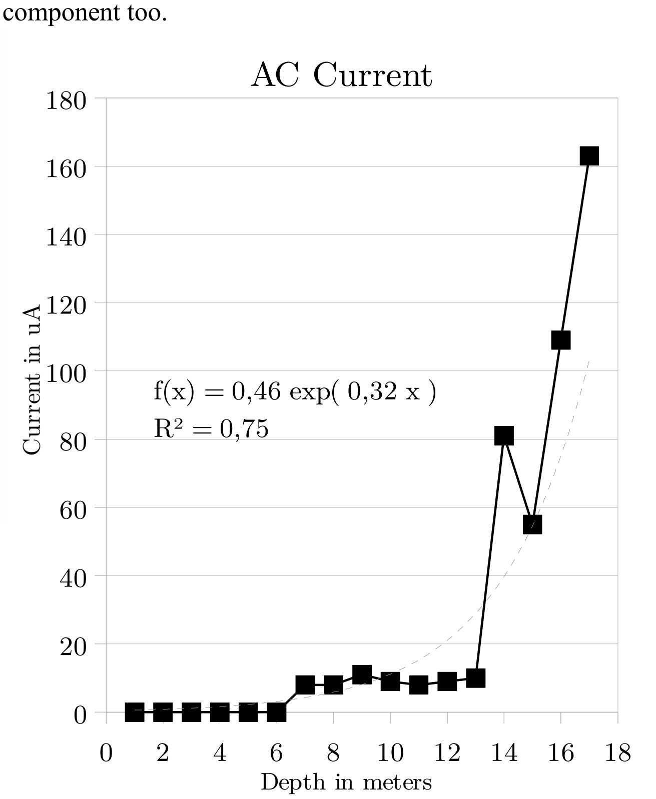

Figure 2: AC current measured at indicated depth against a reference electrode of similar depth in neutral earth.

C. Spectrum analysis

Spectrum composition of the measured current was analyzed both with regards to the HF and ELF parts of the signal.

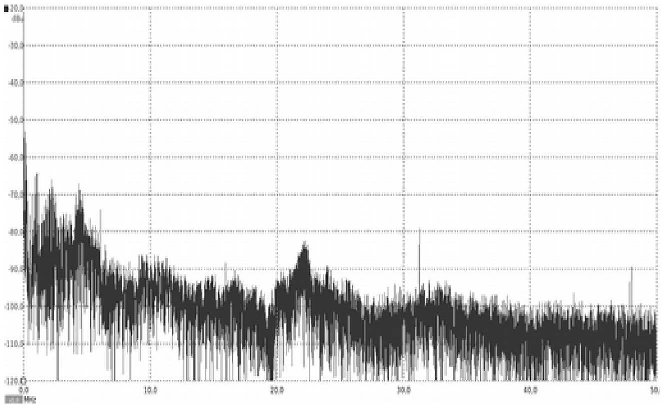

Figure 3: Spectrum composition of the current measured between the measuring probe at 17 meter and reference electrode for the HF frequency span between 0Hz and 50MHz. Note the sharp peak at 32MHz. This is observed in all measurements in the area, whether soil-based or taken from electrical infrastructure. Even with all electrical power to the farm disconnected this peak persists unchanged.

Some parts of the spectrum clearly differs between the different depths, but a single very distinct peak at about 32 MHz persists in all measurements.

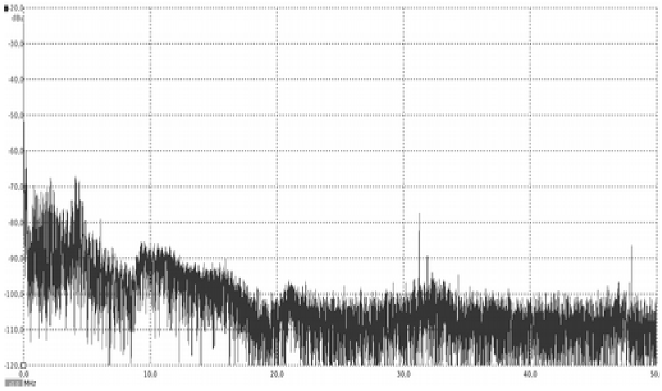

Figure 4: Spectrum composition of the current measured between the measuring probe at 16 meter and reference electrode for the HF frequency span between 0Hz and 50MHz. Note the sharp peak at 32MHz.

Measurements taken from the electrical conducting barn equipment yields a similar spectrum composition where the 32MHz peak still persists.

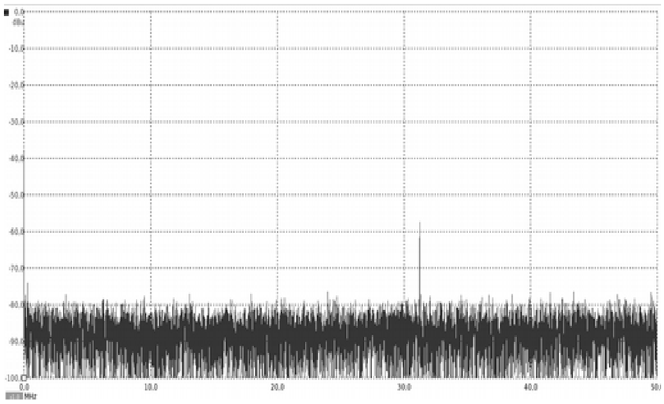

Figure 5: Spectrum composition of the current measured between electrical conducting barn equipment consisting of galvanized steel and reference ground. Note the sharp peak at 32MHz

Even when measurements are done with a E-field antenna with artificial ground plane the 32MHz peak persists

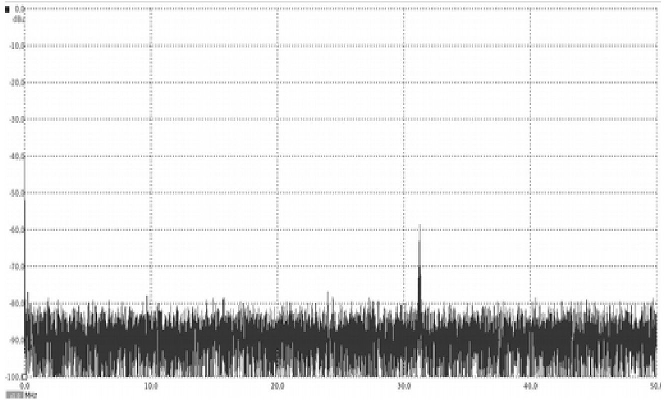

Figure 6: Spectrum composition of the electrical field measured without any electrical contact to earth.

To crudely assess whether this peak could convey any kind of bioreactivity the final measurement was made by connecting a piece of copper bar to the spectrum analyzer measuring probe and holding this copper bar firmly in the hand while standing in rubber boots on a 30mm thick rubber mat.

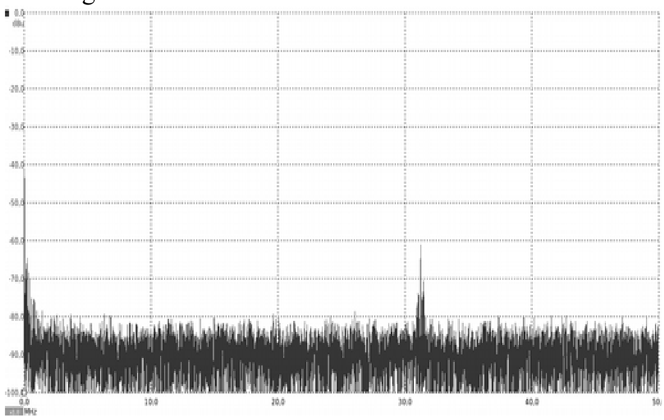

Figure 7: Spectrum composition of the electrical field received capacitively by the human body. Note that the sharp peak at 32 MHz persist.

The measurements indicate a strong capacitative coupling between the human body and the electrical current flowing deep in the ground.

The ELF portions of the spectrum was analyzed separately.

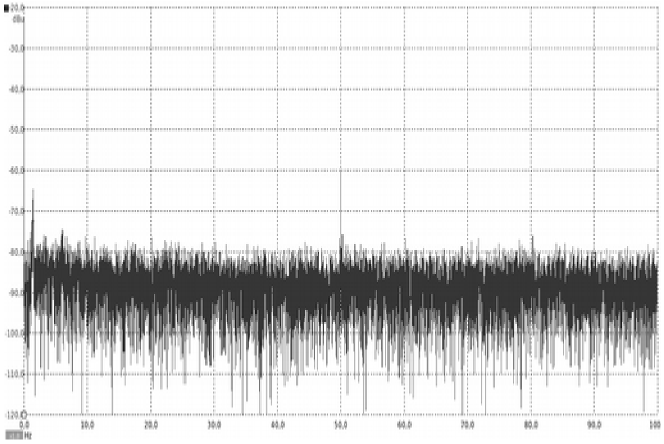

Figure 8: Spectrum composition of the current measured between the measuring probe at 17 meter and reference electrode for the HF frequency span between 0Hz and 100Hz. Note the peaks close to DC.

Measurements taken from the deepest electrodes at the measurement probe indicates a spectrum composition with a strong presence of signals in the extreme low of the ELF spectrum. These signals are rudimentary similar to the ELF signals measured by the means of a magnetic sensor in earlier research.

These ELF components are present in the spectrum composition of all the deepest measurement electrodes

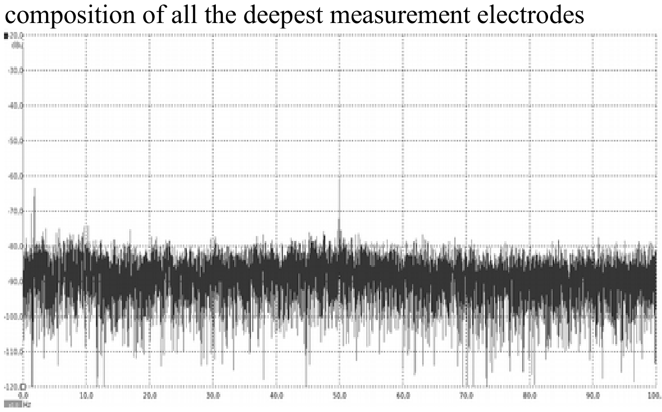

Figure 9: Spectrum composition of the current measured between the measuring probe at 16 meter and reference electrode for the HF frequency span between 0Hz and 100Hz. Note the peaks close to DC

D. **Considerations regarding bioreactivity**

We have registered a maximum reading of 342 uA DC and 163 uA AC. To put these measurements into perspective it should be noted that contact current above 50 uA is associated with negative health consequences for domestic animals [9], [10]. Yet more strikingly, contact current down to 18 uA is statistically associated with increased cancer incidence [11].

It should furthermore be noted that signals exhibiting pulsed nature, especially in the ELF spectrum, is hypothesized (and experimentally verified) to convey a bioreactivity not mediated by contact current, nor mere thermal effects of the signal.

The "*ion forced-oscillation mechanism*" posited by Dimitris J. Panagopoulos [12], [13], [14] describes, with tremendous mathematical detail, how electromagnetic signals modulated by a ELF pattern may influence natural mechanisms governing voltage gated calcium channels and thereby altering the electrochemical composition and functioning of the cell.

It should be noted that this very rigorous mathematical theory has, in contrast to several other theories claiming to have solved the mystery of non-thermal interaction between electromagnetic fields and biological systems, been experimentally verified [15], [16], [17] and confirmed by other researchers [18], [19]. The robustness of the theory has further been documented by the fact that the effects on the cell can be mitigated by blocking the voltage-gated calcium channels pharmaceutically[20].

The effects of the pulsed nature of the stray current encountered should therefore be evaluated along with other known effects.

VI. Conclusion

We have proven that, at least for the measured location, there is a considerable amount of stray current propagated by conductive layers deep in the soil.

We have furthermore proven that, at least for this location, AC current tends to travel in deeper strata.

If these findings are applicable in a wider scope this would seem to indicate that measurements of the magnetic field components in both DC and AC are more suitable for surveying and documenting stray current than actual voltage or current measurements between ground rods.

The spectral measurements of the AC current in the lower strata seems to correlate with the low-frequency variations registered in earlier measurements [1]

The peak registered at 32MHz should be further investigated. The pulsed nature of the current means that biological systems functioning in the area where capacitative coupling to the currents propagated underground may experience bioreactivity as projected by the "*Ion forced-oscillation mechanism"* theory besides the effects more normally associated with stray current.

VII. Future Scope

The measurement setup is configured to automatically take readings of all measurable parameters each second and log these measurement digitally. Further analysis may indicate the need for further measurements to be added to the measurement station. In due time statistical "big data" analysis of the logged measurements may yield new and important knowledge.

The effects of the measured capacitative coupling should be further investigated, especially with regards to which portion of the negative bioreactivity associated with stray current could be attributed to this mechanism.

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Kim Horsevad (kim@horsevad.dk] is the owner and chief technical analyst at Horsevad Independent Technical Research & Analysis (www.horsevad.net). Current research focuses on developing measurement tools for quantifying interactions between electromagnetic fields and biological systems.