Effect of Wire Fences on Slingram Type Surveys

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Resumo

To evaluate the effect of barbed wire fence on ground electromagnetic measurements of slingram type, a series of surveys were done with PROMIS-10 system parallel and orthogonal to it. The fence was fixed on a terrain of relatively simple geology, in which the expected response should be uniform, without remarkable changes. Critical noises appear in the data up to a distance of 20 m from the sensors. In parallel surveys, patterns as "V" and "Λ" shapes are noticed on profiles which are centered on fence position. In orthogonal surveys occur the "W" and "M" patterns. The highest and the lowest frequencies are more susceptible to irreparable noises.

Introduction

After a long period, CPRM has returned to use electromagnetic-EM systems to help re-evaluate their proprietary ore-resource areas and the knowledge of best survey practices has been a challenge for the surveyors. Fences are a common man-made feature in Brazil´s country side and although they are known to disturb the response on EM-systems it is not of our knowledge a practical study of such disturbances on the frequency domain. For the time-domain, Sørensen *et al*. (2001) has published about the effect of galvanic and capacitive coupling.

For this study we chose an area of relatively simple geology, where geophysical responses were expected to be "uniform" and without sudden changes. So, any disturbance due to fences might be better recognizable. It was chosen an isolated plateau at the municipality of Bom Jardim, State of Goiás, Brazil. There were not any man-made objects but one straight barbed wire-fence of more than 400 m long on a grass-land terrain and rare trees. The geology comprises approximately 15 m-thick of Paleozoic Furnas Sandstones over Neoproterozoic Macacos Granite (Seers, 1985) in the State of Goiás, Brazil (Figure 1).

Methods / Investigated Problem

The use of electromagnetic method on the frequency domain is based on the records of the induced secondary magnetic field generated by conductive materials in Earth due to time-varying (primary) field transmitted from an EM system. So, metallic man-made objects like pipes, fences or turned-on engines and power lines are expected to interact with the primary field (anthropogenic noise).

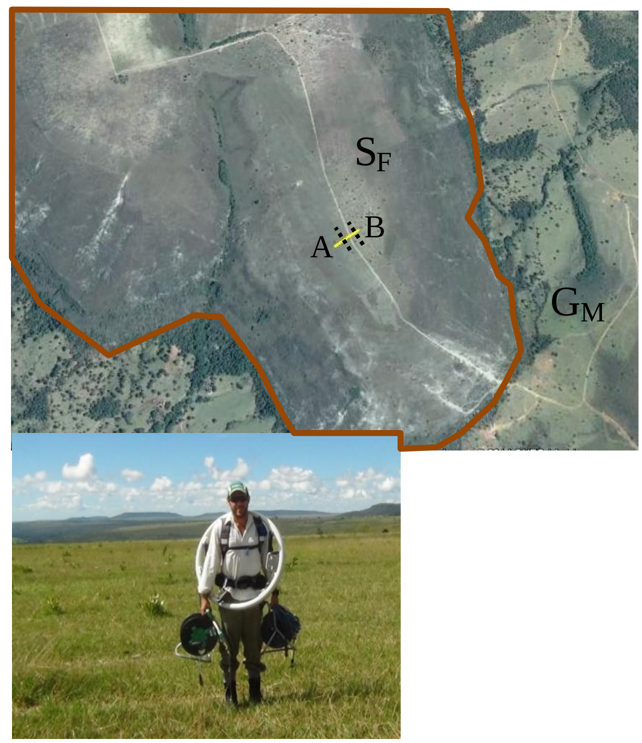


Figure 1 – Location of the study-area at Bom Jardim, Goiás State: a plateau supported by 15 m-thick sandstones overlaid by granite. The fence is along the road. On the Google Earth® image, the reference points A (+80 m) and B (-80 m) mark the beginning and the end of the survey orthogonal to the fence (yellow line). The parallel survey (black dotted lines) are drawn at positions +30 m and -30 m. Approximate scale 1:40,000. S_F: Furnas Sandstone; GM: Macacos Granite. Photo shows the terrain conditions. The brown line is the geologic contact.

The PROMIS-10 (IRIS-Instruments) is a portable *slingram* system, comprised by a transmitter coil-Tx and a receiver sensor-Rx connected by a communication cable, besides batteries and a monitor. It has capability to operate simultaneously in a range of frequencies from 110 to 56,320 Hz as well as to change the sensors separation by using cable lengths from 20, 50, 100, 200 to 400 m, which increase the depth of soundings. The components in-phase and out-of-phase of the secondary magnetic field induced in the ground are measured as percentage of the primary field in a three-coordinate position system: Hz-vertical upwards; Hx-horizontal, towards the profile direction; Hy-horizontal, orthogonal to the profile. The profile is carried out by measuring the adjusted set of frequencies at each station, and by moving both the transmitter and the receiver to the next station. The reading to be located at the half-distance between the sensors.

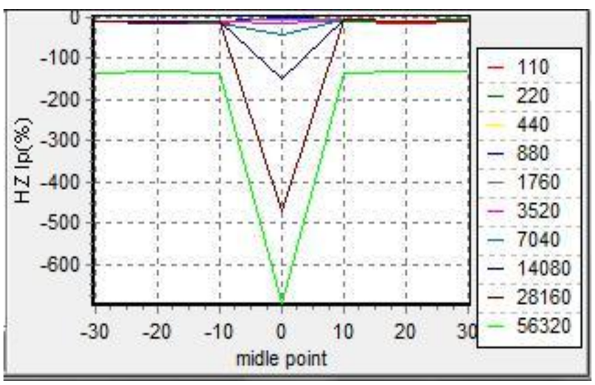
Parallel and orthogonal and profiles were carried out with sensors separations of 20 m (s20), 50 m (s50) and 100 m (s100) and with the fence as “zero” reference. The readings were done every 10 m.

Results

Surveys parallel to the fence, with 20-m and 50-m sensors separation

General pattern is “V” for in-phase data at higher and intermediate frequencies. The “Λ” pattern occurs at lower frequencies. For quadrature or out-of-phase data, the pattern may be either “V” or “Λ” for higher frequencies and “Λ” for intermediate and lower frequencies (Figure 2).

a)



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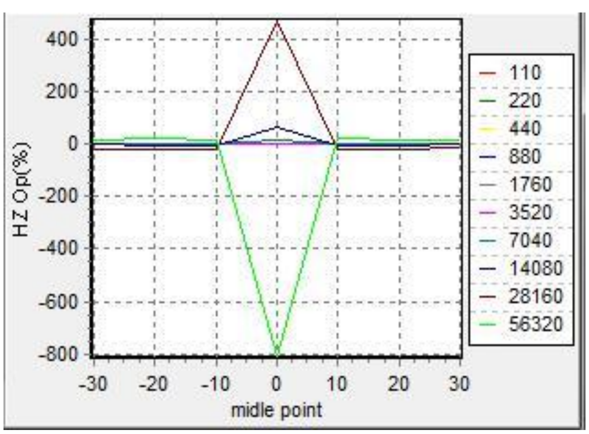
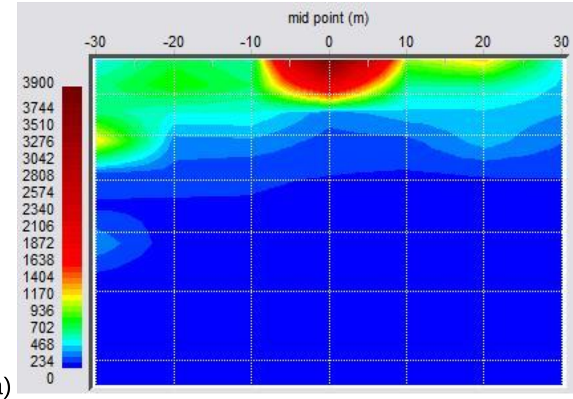


Figure 2 – Behavior of Ip (a) and Op (b) vertical components due to a fence for a survey with 20m-sensors separation and in-parallel to the fence. X-Axis relates to distance from the fence at “0” position. A pronounced peak will appear centered at the fence, with influence up to 10 m from both sides of the fence.

a)



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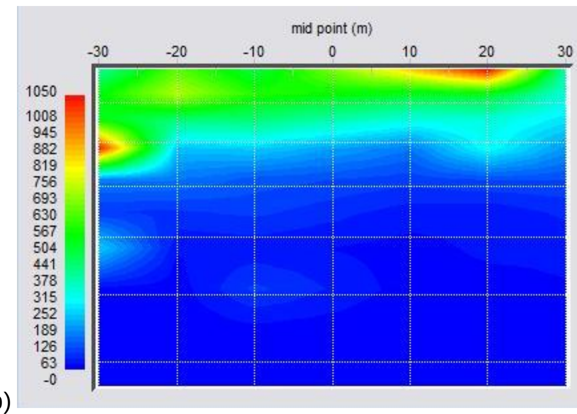
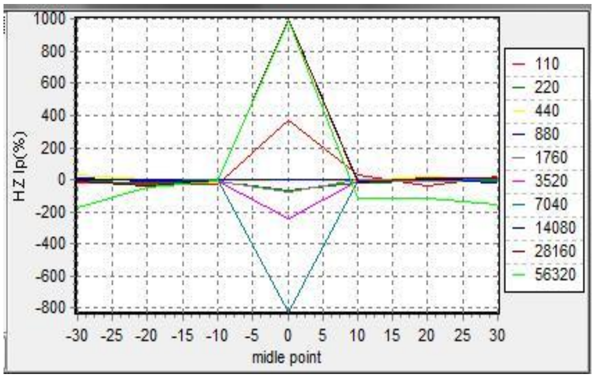


Figure 3 – Apparent resistivity pseudo-section of the data shown on figure 2: a) section accounting for data close to the fence – notice a “bull-eye” anomaly; b) section ignoring the data up to 20 m from the fence (at “0” position). Values in Ohm.m.

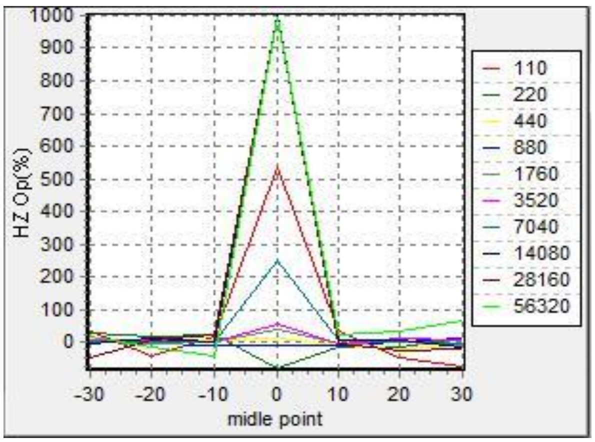
At pseudo-sections of apparent resistivity, the fence creates a prominent false-resistive bull-eye anomaly related to most of the frequencies and centered at the fence location (Figure 3a). However, if the data 20 m aside of the fence is just ignored for computations, a “cleaner” image will better depict the underground as in Figure 3b.

For a survey with 50 m of sensors separation done parallel to a fence, the biggest influences occur similarly as described for s20 m-survey. For In-phase data, highly positive peaks appear for 56320, 14080 e 110 Hz frequencies and highly negative peaks for 7040 to 1760 and 220 Hz frequencies. Frequencies 440 and 880 Hz had a gradational change from positive to negative values centered on fence position (Figure 4a). For out-of-phase data, highly positive peaks are shown at the fence position for all frequencies, except 220 Hz, whose peak is negative (Figure 4b).

The resistivity presentation as pseudo-section also shows a highly-resistive anomaly centered at the fence. Again, if ones ignore the data-points up to 20 m from the fences, the pseudo-section will better show the subsurface structure.



a)



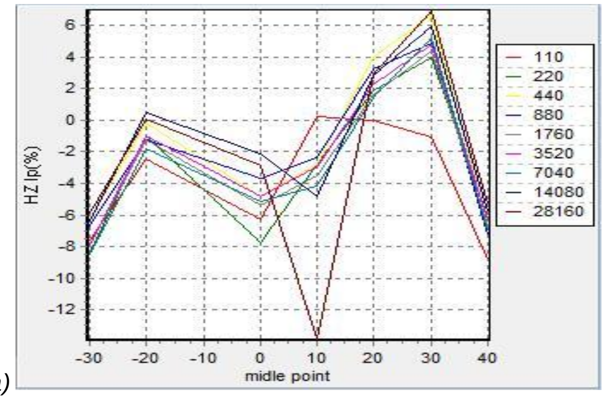
b)

Figure 4 – Behavior of Ip (a) and Op (b) vertical components due to a fence for a survey with 50 m-sensors separation and in-parallel to the fence. X-Axis relates to distance from the fence (at "0" position). A pronounced peak appears centered at the fence, with influence up to 10 m from both sides of it.

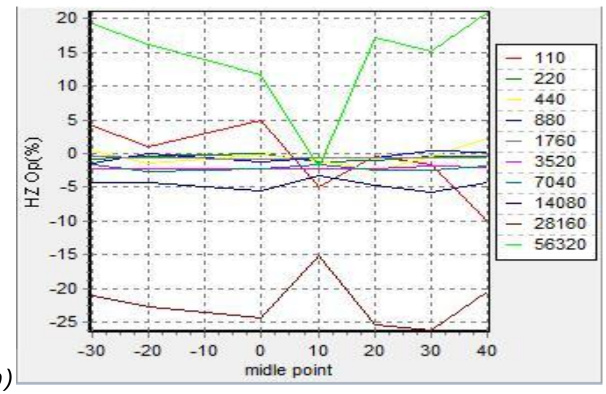
Surveys orthogonal to fence, with 20-m and 50-m sensors separation

For surveys of 20 m sensors separation and orthogonal to a barbed fence, the interferences begin at 20 to 30 m from the fence, mainly with the transmitter at that position. The in-phase profile is characterized by "shoulders" at 20 to 30 m at both sides of the fence and a low-negative centered peak which may be at fence position for the intermediate and lowest frequencies or +10 m aside for the highest frequencies (28,160 and 14,080 Hz). The quadrature profile shows a centered negative peak of very negative values for 28,160 Hz, or slightly negative for all other frequencies –in this case the "shoulders" are not prominent as the in-phase profile. (Figures 5a, b).

For surveys with 50-m sensors separation and orthogonal to fence, the more evident interferences are at about 20 to 45 m from the fence or at the fence. The pattern is roughly "W", where "shoulders" are seen at positions -25 m (Rx next to the fence) and +45 m (Tx at 20 m from the fence), followed by one positive peak at +5 m (fence approximately at half-distance from the sensors) and intermediate lows at +15 m and -15 m. (Figure 6a).



a)



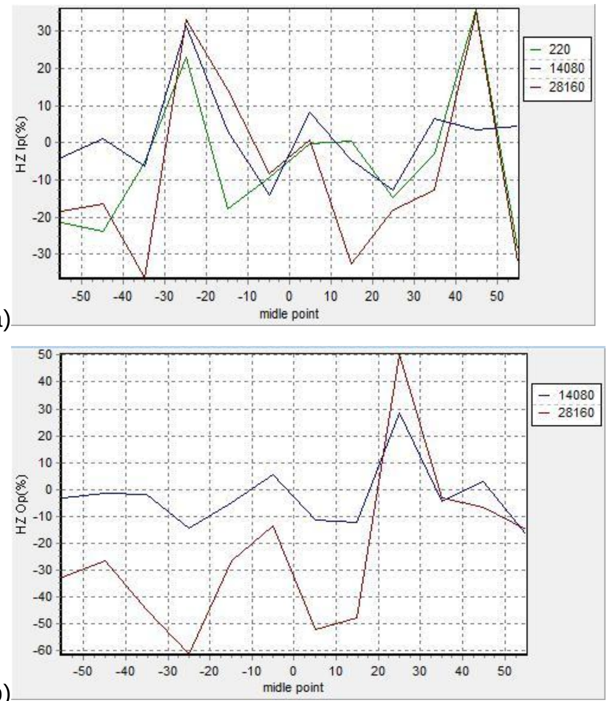
b)

Figure 5 - Vertical component profiles for a survey with 20 m-sensors separation and orthogonal to a fence. Pattern as "M" for in-phase profile (a) centered next to the fence, with "shoulders" associated to sensors proximity to the fence. The quadrature profile (b) exhibits a single negative or positive peak next to the fence at "0" position.

For quadrature profile, the "W" also occurs but the positive central peak is more pronounced and "shoulders" are equal or lower than central peak. The central peak is at -5 (for higher frequencies) or +5 to +15m (for intermediate frequencies). (Figure 6b).

Survey orthogonal to the fence, with 100-m sensors separation

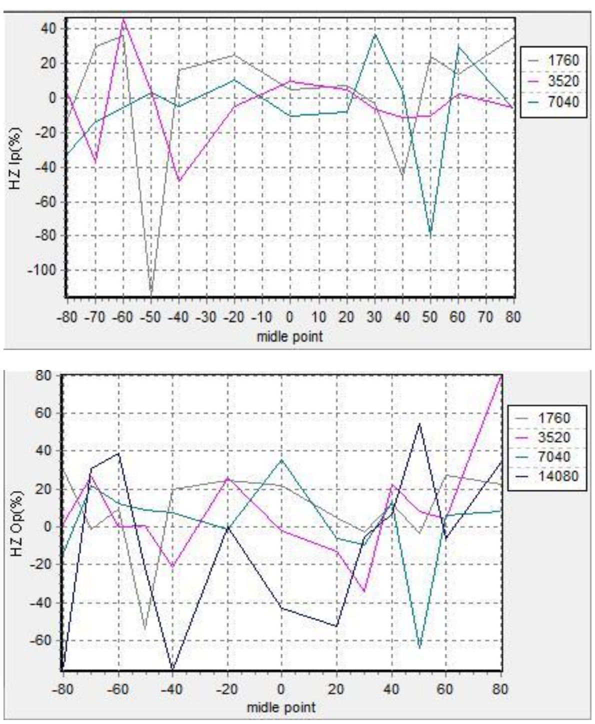
For all frequencies, the greatest influence for the in-phase vertical component occurs when the Rx or the Tx are next to the fence (positions +50 m and -50 m on the profile, respectively), they comprise pronounced positive peaks for the highest frequencies or negative peaks for intermediate frequencies. Less influence occurs when the fence is at half-distance from the sensors. The quadrature data are more disturbed than the in-phase. (Figures 7a, b).



a)

b)

Figure 6 - Vertical component profiles for a survey with 50 m-sensors separation and orthogonal to a fence. Pattern as "W" for in-phase profile (a) centered next to the fence, with "shoulders" associated to sensors proximity to the fence. The quadrature profile (b) also exhibits a "W" pattern, associated to a peak next to the fence. Profiles show higher frequencies and the 200 Hz.



a)

b)

Figure 7 - Figure 6 - Vertical component profiles for a survey with 100 m-sensors separation and orthogonal to a fence. For in-phase profile (a) negative peaks at -50 and +50 m are respectively related to Rx and Tx next to the fence. Such peaks may not appear on both sides of the fence. Less interference occurs in the in-phase than quadrature component when the fence is at half-distance.

The apparent resistivity as pseudo-section shows resistive highs at the fence, that extends 20 m to both sides and minor anomalies at about -50 and +50, related to noise when the sensors are next to the fence. Because of the resistive highs, it is more difficult to filter them to produce a better image of the subsurface. Figure 8.

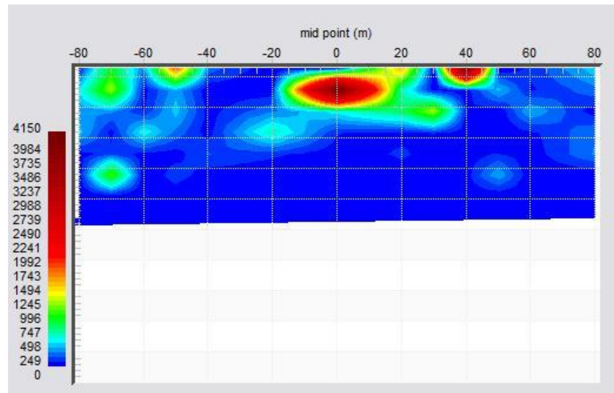


Figure 8 – Apparent resistivity pseudo-section of the data shown on Figure 7. Generalized resistive highs are seen on the image, which difficult the understanding of the subsurface. Values in Ohm.m.

Discussions and Conclusions

The influences of the fence on data set comprise pronounced positive and negative peaks at the in-phase and out-of-phase data profiles. These peaks have specific positions, generally related to the sensors when they are at the fence or half-distance to it. Positive or negative peaks depend on the mutual inductance between the fence, the underground and the sensors. High values are recorded principally from 14080 Hz and higher or below 880 Hz to a distance up to 20 m up to 45 m from both sides of the fence. It was found that 20 m from the fence is a critical distance for the sensors, with huge interference on the measurements.

For a survey with Tx-Rx separation of 100 m or above, the effect of the fence is smaller when it is at half-distance of the sensors because the separation is five times larger than the critical distance. Surveys with 20 m separation are not feasible in a terrain with several fences at distances of less than 50 m from each other.

Peak positions variations may occur and are indicators that the best coupling between the system and the fence varies according to the used frequency or the measurement step.

We recommend that surveys with PROMIS or other *Slingram* system must avoid pipes and fences. Soundings should be taken at a distance of at least 40 m away from any potential anthropogenic source of noise. In case of urban zones, a safe distance is about 200 to 400 m depending on the power line voltage.

Acknowledgements

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Referências

Seer, H. J., Geologia, deformação e mineralização de cobre no Complexo Vulcanossedimentar de Bom Jardim de Goias, Brasilia 1985 – Dissertação de mestrado. Universidade de Brasília, Brasil. 181 p.

Sørensen, K. I., Thomsen, P., Auken, E., and Pellerin, L., 2001, The effect of Coupling in Electromagnetic Data: Proceedings - Electrical and Electromagnetic Methods Session (ELEM), Birmingham, England, EEGS, 108-109. Available at: http://greeninc.us/Documents/coupling_abs.pdf. Accessed on 1 June 2014.