GEOLECTRICAL SURVEY IN THREE AREAS IN BARTON PENINSULA NEAR THE KING SEJONG KOREAN ANTARCTIC STATION

CAMPANHA DE PROSPECÇÃO GEOELÉCTRICA EM TRÊS LOCAIS NA PENÍNSULA DE BARTON JUNTO À ESTAÇÃO ANTÁRCTICA COREANA REI SEJONG

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Abstract: With the objective of trying to find a correlation between electrical resistivity values of the ground and the existence of different kinds of mosses and liquens, a geoelectrical survey using the electrical resistivity tomography methodology was used in three areas near the King Sejong Korean Antarctic Station. The geoelectrical models obtained for most of the profiles in the three areas of this work indicate that permafrost exists at depths deeper than 0.6 m. Because of lack of vegetation information no correlation between the electrical resistivity values and the existence of mosses and liquens at the surface of the ground can be inferred. More geoelectrical surveys are necessary. Some care should be taken, though, when doing the geoelectrical work because the ground near the King Sejong Antarctic Station presents very high electrical ground resistances.

Key words: ERT, permafrost, King Sejong Korean Antarctic Station, King George Island, Maritime Antarctica.

Resumo: *Uma campanha de prospecção geoeléctrica utilizando o método da tomografia de resistividade eléctrica foi realizada em três áreas junto à Estação Antárctica Coreana King Sejong com o objectivo de tentar correlacionar a resistividade eléctrica do solo com a distribuição de diferentes tipos de musgos e líquens aí existentes. Os modelos geoeléctricos obtidos ao longo da maioria dos perfis tomográficos realizados indicam que permafrost existe para profundidades superiores a 0,6 m. Contudo, por falta de informação sobre a distribuição da vegetação em cada uma das áreas, nenhuma correlação entre a resistividade eléctrica do solo e a existência de musgos e líquens pôde ser inferida. Mais campanhas de prospecção geoeléctrica são necessárias; contudo, algum cuidado deve ser considerado aquando de novas companhas de prospecção geoeléctrica já que, devido às características do solo junto à Estação King Sejong, as resistências eléctricas de contacto entre os eléctrodos de corrente e o solo são muito elevadas.*

Palavras chave: *Tomografia de resistividade eléctrica,* permafrost, Estação Antárctica Coreana Rei Sejong, Ilha Rei Jorge, Antárctida Marítima.

I. INTRODUCTION AND OBJECTIVES

Under the framework of the project "PERMATOMO" of the Portuguese Polar Program and the project "Long-term Ecological Researches on King George Island to predict Ecosystem Responses to Climate Change" of the Korea Polar Research Institute a geoelectrical survey using an electrical resistivity tomography (ERT) technique was used in four areas in Barton Peninsula of King George Island. The main idea of the field work was to start geophysical monitoring in different sites in the King Sejong Korean Antarctic Station in Barton Peninsula with the objectives of mapping permafrost and active layer and correlate their actual changes in time with long-term ecosystem response to climate change and trying to quantify moisture content of the active layer and wet permafrost. Furthermore, this first year of field work would allow to start a more comprehensive program of permafrost and active layer monitoring for long-term study of ecosystem responses to climate change using three different geophysical techniques, i.e., electrical resistivity tomography, in 2017, and ground penetrating radar and seismic tomography in the following years (Davis and Annan, 1989; Benjumea *et al*., 2003; Hauck and kneisel, 2008; Conway *et al*., 2009).

As a preliminary result of the electrical resistivity tomography acquisition two-dimensional electrical resistivity models for three of the four sites mentioned above were obtained and will be useful in constructing three-dimensional electrical resistivity model in the future.

The data and information collected during the field work will hopefully contribute to clarify scientific aspects related with key questions 42 and 49 described by Kennicutt *et al*. (2014, 2015).

II. FIELD WORK AND PRELIMINARY RESULTS

The field work carried out in the three areas near the King Sejong Antarctic Station took place between January 15 and February 10, 2017. The three areas have gentle topography but are very rocky; different kinds of mosses and lichens appear as patches of different dimensions. The rocky characteristics of the areas chosen to carry out the electrical resistivity tomographies make the areas very difficult to inject current into the ground; as a matter of fact, that was the main problem of the geoelectrical survey and in some cases it dictated the impossibility of doing the ERTs. Only the areas from now on called GYM (about 10 m a.s.l.), POND (about 25 m a.s.l.), and MONITORING (about 6 m a.s.l.) sites will be discussed here; in a fourth area it was not possible to obtain any ERT data; as a matter of fact, it was not possible to inject any current into the ground because of the very high electrical contact resistances. The ground surface in MONITORING and POND sites is very similar (see Figures 4 and 6); it is basically composed of relatively big rock clasts with some patches of lichens and mosses. On the contrary, the POND site is composed of relatively small rock clasts and abundant patches of lichens and mosses.

Figure 1. King Sejong Antarctic Station in Barton Peninsula in King George Island. The ellipses in red show the approximate areas where electrical resistivity tomography profiles were done.
Figura 1. Estação Antárctica Rei Sejong na Península de Barton da Ilha Rei Jorge. As elipses a vermelho indicam as áreas aproximadas em que foram realizadas tomografias de resistividade eléctrica.

Two resistivity meters were used for the geoelectrical field work: an ABEM LS and a Lippmann LG High Power. Because of the highest power of the ABEM in comparison with the Lippmann, problems with high contact resistances were more frequent with the Lippmann than with the ABEM. Each ERT profile was 20 m long with 41 stainless electrodes separated by 50 cm; the electrical data were obtained using a Wenner configuration. Because of the rocky ground and high electrical contact resistances the time to make an ERT was, on average, one and a half day. Figure 1 shows the location of the three areas were ERTs were carried out. Figures 2 to 7 show the areas and the geoelectrical models that were obtained by inversion of the ERT profiles carried out in the areas of Figure 1. For inversion of the geoelectrical data the RES2DINV software was used (Loke and Barker, 1995, 1996). In a chronological manner the first area to be considered for a geoelectrical survey is not shown because it was impossible to inject current in the ground; that area was then abandoned and the next area was the POND area shown in Figure 1. The POND area is a 15 m by 15 m gentle slope area (Figure 2); several parallel ERT were planned to be carried out there; however, because of time, weather and logistic conditions only one ERT was carried out along the less elevated horizontal area limit.

Figure 2. Picture of the POND area. In white are the limits of the area where the ERTs should be done. Actually, only one ERT (yellow double arrow) was carried out along the less elevated limit shown in the figure.
Figura 2. Fotografia da área POND. Os limites da área estão representados por linhas brancas. Uma tomografia de resistividade eléctrica foi realizada ao longo do limite inferior da área representada na figura (seta a amarelo).

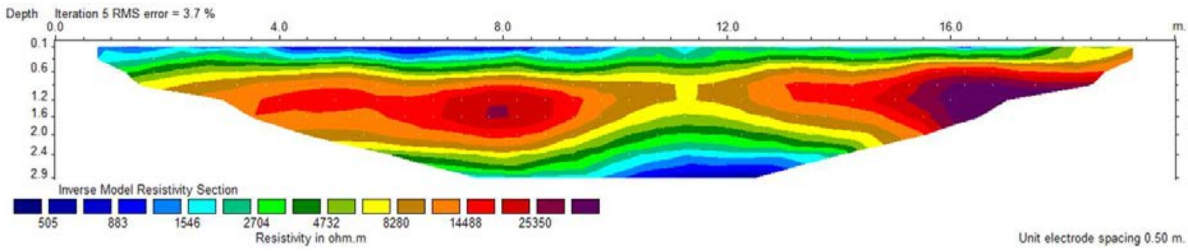

Figure 3. Geoelectrical model of the ERT carried out in the lower limit of the POND area of Figure 2. Blue regions represent low electrical resistivity values and red and purple regions represent high electrical resistivity values. Permafrost or frozen ground appear to exist between 0.5 to 1.6 m.
Figura 3. Modelo geoeléctrico obtido ao longo do limite inferior da área representada na Figura 2. As manchas azuis correspondem a valores relativamente baixos da resistividade eléctrica enquanto as manchas vermelhas e roxas correspondem a valores elevados da resistividade eléctrica. Permafrost ou solo gelado parecem existir entre os 0,5 e 1,6 m de profundidade.

Figure 3 presents the geoelectrical model along the lowest limit of the area shown in Figure 2. High electrical resistivity values are represented by blue colors and high electrical resistivity values are represented by red and purple colors. The geoelectrical model represents a vertical section 20 m long with a deepest depth of investigation of about 3 m in the central area of the model. The general trend of the underground electrical structures is horizontal and high electrical resistivity values are interpreted as frozen ground or permafrost. It is interesting to note that below about 2.5 m depth regions of low electrical resistivity appear again. Relatively low electrical resistivity values are observed at the surface of the model, probably indicating higher moisture content of the superficial ground. A few meters down slope of the ERT profile there was a lake of melted water.

The MONITORING area, shown in Figure 4, is a 15 m by 30 m almost horizontal area; only one electrical resistivity tomography was carried out in the area. Several ecology studies are being done there and two shallow boreholes about 60 cm deep were excavated for temperature and moisture monitoring. The geoelectrical model obtained from the ERT profile can be seen in Figure 5. In the same location of the ERT profile the resistivity meter was installed in a monitoring way to evaluate the evolution of the ground electrical resistivity during several months to compare with moisture and temperature changes. In the middle of Figure 4 a black box where the resistivity meter was installed in a permanent way can be seen; orange cables that connect the stainless electrodes with the resistivity meter inside the black box.

Figure 4. Picture of the MONITORING area described in the text. In white are shown part of the limits of the area where 2 shallow boreholes for temperature and moisture monitoring were excavated. The ERT was done along the left limit in the picture (yellow double arrow) where the cables in orange and the stainless electrodes can be seen. The black box on the top contains the resistivity meter which will continue to monitor the ground resistivity in an automatic way.

Figura 4. Fotografia da área MONITORING descrita no texto. Parte dos limites da área onde foram escavados dois furos para monitorização da temperatura e da humidade do solo estão representados por linhas a branco.
A tomografia de resistividade eléctrica foi realizada ao longo do limite mais à direita da fotografia (seta dupla a amarelo). onde se podem ver os cabos e os eléctrodos de aço. A caixa preta no topo da fotografia contem o resistivímetro para monitorização contínua da resistividade eléctrica do solo.

Figure 5 presents the geoelectrical model along the profile shown in Figure 4. Again blue colors represent low electrical resistivity values while red and purple colors represent high electrical resistivity values. Contrary to what happens in the geoelectrical model of Figure 3, the underground structures are not horizontal; as a matter of fact, there is a small basin in the middle of the model with low electrical resistivity values with a couple of high electrical resistivity values at the surface which can be caused by local rock heterogeneities. The basin is bounded by two high electrical resistivity uplifts which can be interpreted as frozen ground or permafrost. It is also interesting to note that the two boreholes that were excavated inside the MONITORING area reached depths of 60 cm and no frozen ground or permafrost was detected. It is also noteworthy that the electrical resistivity values of this geoelectrical model are much lower than the electrical resistivity values found in all other ERT profiles carried out in the other areas shown in Figure 1.

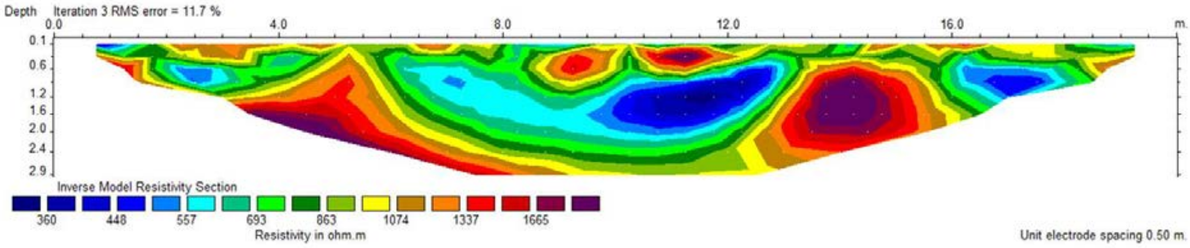

Figure 5. Geoelectrical model of the ERT carried out in the left limit of the MONITORING area of Figure 4. Blue regions represent low electrical resistivity values and red and purple regions represent high electrical resistivity values.
Figura 5. Modelo geoeléctrico obtido ao longo do limite inferior da área representada na Figura 4. As manchas azuis correspondem a valores relativamente baixos da resistividade eléctrica enquanto as manchas vermelhas e roxas correspondem a valores elevados da resistividade eléctrica.

Figure 6 shows a general view of the GYM area which is 15 m wide by 40 m long. Initially it was planned to carry out ERT profiles every 5 m perpendicular to the longest side of the rectangular area. However, because of time constraints, only two ERT profiles separated by 5 m were done (GYMline 1 and GYMline 2) (Figure 6). The area is very rocky and presents some topography which will not be considered in the processing of the data because it is not known at the time of the writing of this abstract. Figures 7 and 8 show the geoelectrical models for the GYMline 1 and GYMline 2 ERTs. There were many problems to carry out the ERTs because the electrical contact resistances were very high; to be able to inject current into the ground it was necessary to dig small holes around each stainless electrode and fill them with mud and water to decrease electrical resistances.

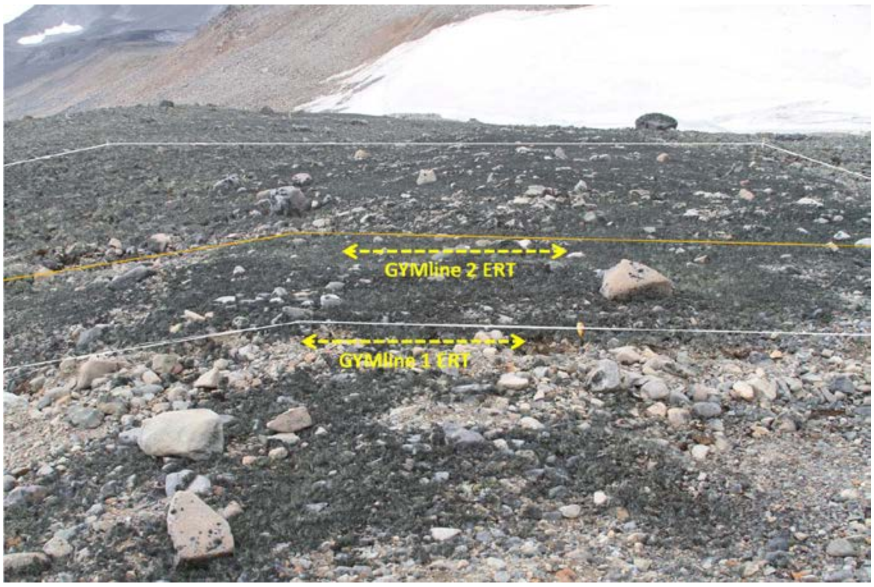

Figure 6. Picture of the GYM area. In white are shown parts of the limits of the area. The two ERT profiles done are also shown (yellow double arrow). GYMline 1 coincides with the nearest limit of the GYM area.
Figura 4. Fotografia da área GYM. Parte dos limites da área estão representados por linhas a branco. Os dois perfis de resistividade eléctrica realizados também estão representados (seta dupla a amarelo). O perfil GYMline 1 coincide com o limite mais próximo da área GYM.

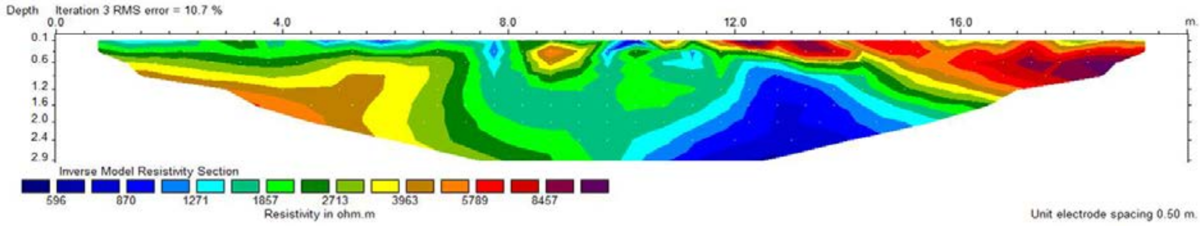

Figure 7. Geoelectrical model of the GYMline 1 ERT carried out in the GYM area of Figure 6. Blue regions represent low electrical resistivity values and red and purple regions represent high electrical resistivity values.
Figura 5. Modelo geoeléctrico do perfil GYMline 1 da área representada na Figura 6. As manchas azuis correspondem a valores relativamente baixos da resistividade eléctrica enquanto as manchas vermelhas e roxas correspondem a valores elevados da resistividade eléctrica.

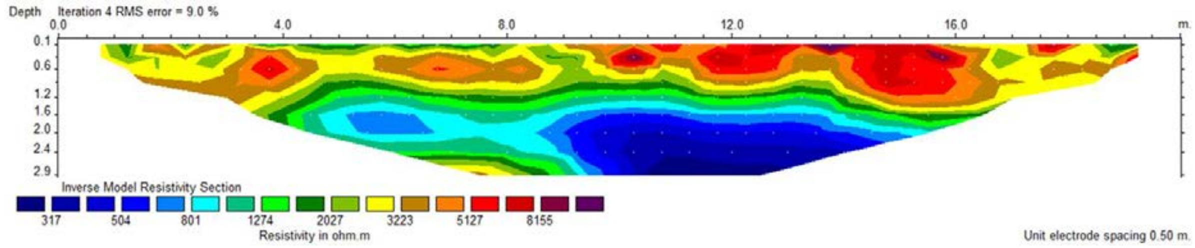

Figure 8. Geoelectrical model of the GYMline 2 ERT carried out in the GYM area of Figure 6. Blue regions represent low electrical resistivity values and red and purple regions represent high electrical resistivity values.
Figura 8. Modelo geoeléctrico do perfil GYMline 2 da área representada na Figura 6. As manchas azuis correspondem a valores relativamente baixos da resistividade eléctrica enquanto as manchas vermelhas e roxas correspondem a valores elevados da resistividade eléctrica.

III. CONCLUSIONS

The electrical resistivity tomography profiles and the electrical resistivity models obtained in the three areas near the King Sejong Antarctic Station show that those areas are quite different from each other. Electrical resistivity values are lower in the MONITORING site and higher in the POND site. However, the POND site was the area where the field work was easiest to do and the electrical resistances between the stainless electrodes and the ground were the smallest. In all electrical resistivity models obtained for the three areas the existence of frozen ground or permafrost is apparent.

An important piece of information which would allow interpreting some portions of the obtained geoelectrical models came from the workers who are constructing the new building of the King Sejong Antarctic Station; they detected permafrost between 0.6 and 1.5 m depth in the construction area; of course that the areas where the geoelectrical surveys were carried out are a few hundred meter away from the construction area. Actually, most of the geoelectrical models shown here indicate high electrical resistivity values below 0.6 m depth, which is a good indication that those values must represent permafrost.

One of the main objectives of the geoelectrical surveys in the areas described above is to try to identify any correlation between electrical resistivity values and the existence of mosses and lichens; at this stage of the work nothing can be said about that possible correlation; further information about local vegetation and more geoelectrical surveys are necessary.

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