Geophysics to Groundwater Knowledge in Martim Pescador District-Urupá, Rondonia-Brazil

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Abstract

The purpose of this research is to obtain information and knowledge on the occurrence, and potential use of groundwater in the area of the Plan Settlement Martin Pescador (PA Martin Pescador) . The Geological Survey of Brazil (SGB / CPRM) develops several programs for the knowledge and the use of groundwater nationwide, which comes against the line of research established by the Ministry of Science and Technology which also applies to the object area study .

This document it is a report containing technical data organized to assist the planning of decision making for the construction of deep wells in the catchment area of PA Martin Pescador

Introduction

This project refers to the result of a geophysical study in the small part of Parecis sedimentary basin, Pimenta Bueno Gabren, located in the central portion of the Rondonia state, between the cities of Porto Velho and Alvorada d'Oeste.

The geophysical method applied was the resistivity, being carried out by the technique of vertical electrical sounding (VES). Geological and hydrogeological aspects were also found at the regional and local context in which it appears the PA Martin Pescador, with the aim of identifying geological conditions favorable to the construction of deep wells, targeting the groundwater use in the best way.

The main objective of this research was to indicate the thickness variations of sedimentary packages as well as investigate the existence of discontinuities that may be present in the physical environment. Thus, the information obtained will form the basis for identification of favorable local building wells for groundwater extraction, intended for human consumption, in order to contribute in the implementation of water infrastructure actions to support policy land reform settlement project.

The study area is located in the central portion of the state of Rondônia , specifically on the border between the cities of Porto Velho and Alvorada d'Oeste , the Plan Settlement Martin Pescador, in an area of 181.83 km² . The access from the city of Porto Velho is accomplished through the federal highway BR -364 to the town of Ouro Preto do Oeste on a journey of approximately 332 km , taking then the state highway RO-473 for about 70 km to the city of Porto Velho(figure 1).

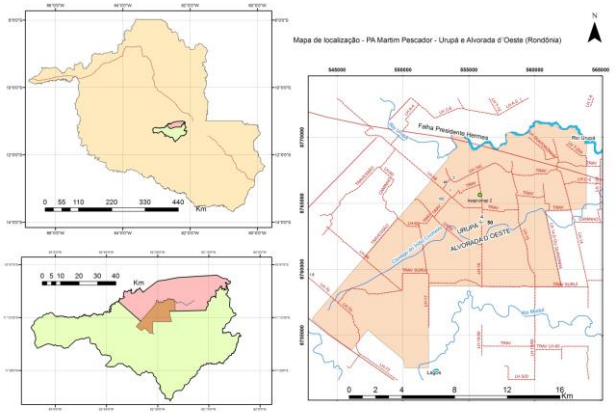

Figure 1 - Research Area Location Map - Area Location in the state of Rondônia - Area Location PA Martin Fisherman on the municipal boundary of Porto Velho and Alvorada d'Oeste - PA Martin Pescador location detail

Method

To achieve the proposed objectives, the research was conducted in three main stages:

First Step: performed in the laboratory comprising a superficial analysis of the studied area and the collection of technical data from existing wells in the region; In this step we used several maps (scale 1: 100,000) - Geological Map of the State of Rondônia (scale 1: 1,000,000) and satellite images (compatible scale of 1: 25,000); the creation of a database in GIS platform and the generation of base maps for field use.

Second Stage: Field survey itself, implementing 25 (twenty five) Vertical Electrical Soundings (VES) with schlumberger arrangement. The equipment used for field measurements was a Sycal Pro 10 channels, French-made by Iris-Instruments. Also flexible wiring coils were used 1,5 mm², AB electrodes of solid stainless steel electrodes and MN of solid copper and battery (12V) as a source of electric charge. A calculator was used to calculate the apparent resistivity curves enabling the construction (AB resistivity x / 2) on graph paper with bi-logarithmic tag, which allowed the monitoring of changes

in the resistivities, and fixes and / or ratified some reading.

Third Step: Post-Course is the processing activity and interpretation of the data obtained using the Excel program, IPI2WIN, model generation and the preparation of the final report with data and analysis of prospecting work.

Geological and Hydrogeological Aspects

As the Geological Map of Rondônia (CPRM, 2007) the PA Martin Pescador, is geologically formed by Paleozoic sedimentary Pimenta Bueno and Pedra Redonda Formation, who often present themselves fractured.

The Pimenta Bueno formation consists of shales and siltstones, both brown-chocolate, and micaceous fine sandstones alternate rhythmically in the centimeter scale. The shales are pale brown, micaceous, interspersed with brown siltstone or sandstone clear (figure 2). The sandstones are brown with light spots, mid-grade quartz stations, feldspar and muscovite. Sedimentary environment transitional, sedimentary system, fluvial deltaic, marine / lacustrine.

Pedra Redonda Formation consists of paraconglomerates and coarse sandstones (tillites and diamictic), supported by array, with clasts ranging from pebbles to boulders of systolic, gneiss, granite, amphibolite, shale and limestone. Sedimentary environment continental sedimentary lake system glacial. Tectonic setting - divergent environment basin and / or intraplate includes diamictite sandstone tillite.

Figure 2 - Appearance billing chocolate-brown shale

In PA Martin Pescador land dominated by low water potential aquifers, with generally lower flow rates to 10m3/h. The hydrogeological potential due to the billing of the rocks, behaving so as fractured aquifers.

Aquifer System intergranular / fracture

This system consists of the Pimenta Bueno and Pedra Redonda formations, characterized by the predominance of silt, shales and siltstones fractured, also occurring sandstones arcosianos, limestone and paraglomerados. Fine sediments have a very low permeability and its potential aquifer is subject to the existence of open and interconnected fractures, while the sandy sediments can behave as intergranular aquifers

This system is performed directly by rainwater that seeps in fractures in areas where the shales and siltstones outcrop or through the interstices of the sandstones where they arise or from percolation on the weathering mantle.

Often this aquifer system is enhanced by the occurrence of a weathering mantle consists of sandy-clayey detrital materials with variable thickness, reaching 15m. This coverage feeds the underlying fractured aquifers, forming a single aquifer system.

As yet there is a water supply system, the population captures groundwater through dug wells (ponds). This is a quick and inexpensive alternative, which generally obtain water in sufficient volume to supply one family (1000 liters / day).

The capture wells excavated soil residual water shale and sandstone which is particularly large in the first part of the substrate of the urban area. The material is predominantly clay-sandy, with low permeability. Although providing rudimentary building techniques, the ponds are quite appropriate for low transmissivity aquifers because as have large diameter also serve as storing large volume of water. These wells dug, however, in the dry season (from July to September) tends to lower significantly its static level.

It was found that after a search of the Database System Groundwater Information - SIAGAS (www.cprm.gov.br), surrounding the PA Martin Pescador, was not found well data (flow, depth, level static and dynamic level). Spot it was found that there are six (06) wells constructed in PA Martin Pescador, and only one (01) has constructive profile.

In this region, the majority of drilling wells is carried out by businesses with poor machinery, thus affecting only the less compact band of approximately 40 m; such as the following well log: static level (NE) 19.42; Profile lithologic 0-10m clay soil color chocolate; 10 to 43m shale (photo 5); below this depth is more compact material into which the perforation has been completed. Approximately 200 meters from this there is a well with a depth of 52m and 26m static level of showing a sharp hydraulic gradient of approximately 7m in a small area (Figure 3).

Figure 3 - Well with flow 7 m³ / h , for community supply

Results

The analysis and final interpretations followed the following steps:

-Qualitative analysis of field data: VES

-Quantitative -analysis of product processing and shaping inversion

-Qualitative-analysis of the raw data integrated with resistivity profiles

Qualitative analysis

Qualitative analysis is the first stage of interpretation of survey curves of apparent resistivity, which is taken into account the shape of the curve. Teford et al (1998) proposed a classification field curves based on relative variations in the apparent resistivity, which can be easily classified in three layers of four basic power curve shapes.

In the nesting area identified four patterns of curves based on the type presented by Telford, with the vast majority comprised pattern H and the other combination of other patterns. The VES 25 were classified into the following types: H (13), KH (04), HA (05) and QH (03), as shown in Table 1.

Tipo	Sondagem Elétrica Vertical
H	01, 03, 05, 06, 07, 13, 14, 15, 17, 19, 20 e 23
KH	04, 08, 09 e 21
HA	02, 11, 12, 16, 18 e 22
QH	10, 24 e 25

Table 01 - classification of geo -electric curves performed in this project

In standard SEV H, 03 were interpreted geo -electric horizons, from top to base, as follows:

First very resistive horizon corresponding to unconsolidated weathered surface and sandy soils;

According horizon resistive character, but with lower resistivity than the previous horizon , possibly exhibiting the water level in this field is observed in well Amazons / water hole in many places has intermittent character in the dry season .

Third conductive horizons the resistive indicates a thick sedimentary package of pelitic nature and may be resistive lenses, the conduct of field curve in this case merge sandy sediments (Figure 4).

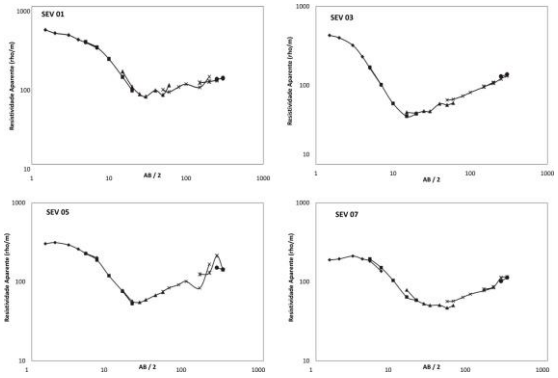

Figure 04 - electrical resistivity curves of the VES 1, 3, 5 and 7 Concerning the standard H.

The VES 11 and 12 represent the southeastern part of the PA Martin Pescador, with the same pattern of behavior, arranged on the sediments of training Pimenta Bueno, separated into 04 geo-electric horizons.

First resistive horizon corresponds to the residual ground formed from the pelitic intercalation / sandstone sediment.

According horizon average resistivity smaller than the resistivity of the first layer may be related to the level of saturated soil. Third and fourth layer represents a conductive thick sedimentary package where these layers have a slight difference in resistivity, and the fourth layer having little higher resistivity than the third (Figure 5).

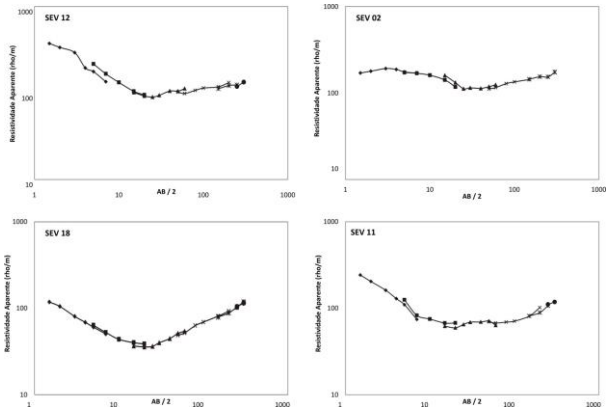

Figure 05 - electrical resistivity curves of VES 11:12.

Surveys 24, 25 and 10 show similar pattern, representing the central portion of PA Martin Pescador. Related to standard QH has the following provision:

First geo- electrical horizon corresponds sandy, weathered and resistive soil that covers the central portion of the area.

According geo-electric horizon lower resistivity than the first horizon, indicates the presence of shallow aquifer commonly intermittent character, observed in Amazon / ponds wells.

Third geo-electric horizon shows a sharp drop in resistivity of a conductive medium.

Room geo- electrical conductive horizon character indicating a thick sedimentary package, possibly pelitic nature and possible interbedded with sandy sediments, evidenced by the behavior of the field curve (Figure 6).

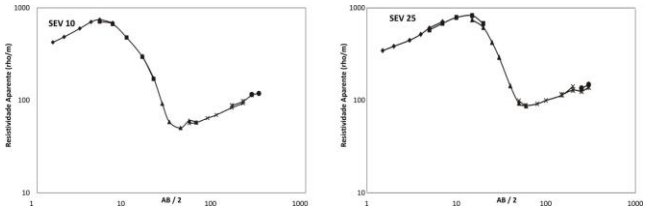

Figure 06 - electrical resistivity curves of VES 10:25

The VES 04, 08, 9 and 21 represent the standard KH and are characterized as:

First resistive horizon corresponds to the residual ground formed from the pelitic intercalation / sandstone sediment

According to the horizon has a higher resistivity than the first layer , possibly due to a shallow depth laterite horizon and not too thick .Third geo -electric horizon shows a sharp drop in resistivity of a conductive medium. Room geo- electrical conductive horizon character indicating a thick sedimentary package (Figure 7)

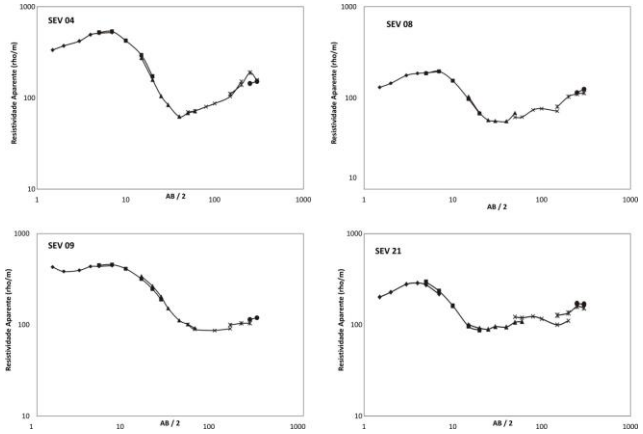

Figure 07 - electrical resistivity curves of the VES 04 , 08 , 9:21

In accordance with the Geological Map of the State of Rondônia (Quadros e Rizzotto, 2007), the VES were organized according to surface geology, in 03 groups:

• Group I - VES arranged in the region that dominates the formation Pimenta Bueno - SDpb (a) - fine sandstone and micaceous

• Group II - VES arranged in the region that dominates the formation Pimenta Bueno - SDpb (f) - ritimicas interbedded shale and sandstone.

• Group III - VES arranged in the region that predominates Pedra Redonda- C1pr - containing paraconglomerates and coarse sandstones.

The geo-electric curves related to group I, KH and type HA, represented by VES 21:22 have different patterns depending on the region of the SEV 21 have a higher content of laterite rock outcropping, and higher resistivity variation in depth, and more homogeneous this change in SEV 22. In Group II, there are all kind of geo-electric curves with the following distribution H (8), KH (3), QH (2) and HA (5), where all polls end with an ascending branch, indicating a thick layer probably related to pelitic sediments of shale. No Group III, the curves are predominant pattern H, with a survey of QH standard, which both end with ascending pattern in 45 indicating a thick layer.

Analysis Geological Interpretative

At this stage of work, all the surveys were interpreted by the method Ridge Regression (Tikhonov & Arsenin, 1977), using the IPIwin2 software to estimate the thickness of geo-electrical layers as well as their respective resistivity. For a correct interpretation of the geophysical data are needed concrete information of the local geological conditions such as information from existing underground wells in order to interact and format the appropriate mathematical model adjustments to step inversion of the data. In the search region no data that could be used for calibrating the inversion model. The model adjustments were made to the interaction of known geological reality, surface mapping data and Amazons / ponds wells.

The most of the surveys allowed a theoretical research about 150m deep, where most of these VES focused on interleaved unit training Pimenta Bueno. Surveys located in the northern portion of the PA Martin Pescador have generally three geo-electrical layers relatable to the saprolite. The first layer is resistive, attributed to shallow soils package with lateritic change contribution, ranging from 380-800 ohms / m, with a depth of about 1.80 m to 2.20 m. A second layer resistivity ranging 230-350 ohms / m is the top of the water aquifer, with an average thickness ranging from 4.20m to 5.00m. The third layer is geo-electrical low resistivity ranging between 20 and 40 ohms / m, 6 to 12m thickness, such that the limit of 12 to 18 m deep. These three layers that make up the saprolite is the decomposition of the rock through the weathering, this limit also marks the water and intermittent unconfined aquifer, which remains during the rainy season. A fourth geo-electric layer resistivity variant 50-140 ohm / m to thickness variations and two groups, the first being 50m to 70m, and the second 130m to 120m (Figure 08).

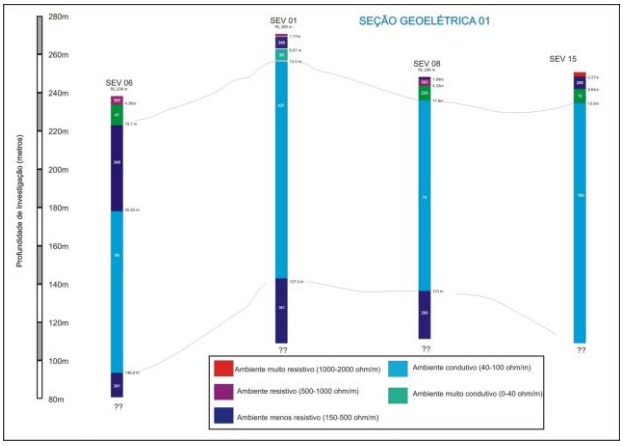

Figure 08 - Profile 01 - North Portion PA Martin Pescador

The geo-electric section 02 located in the central portion of the search area, has similar behavior with the geo-electric section 01. However the 4th layer of this section has thicker (Figure 09).

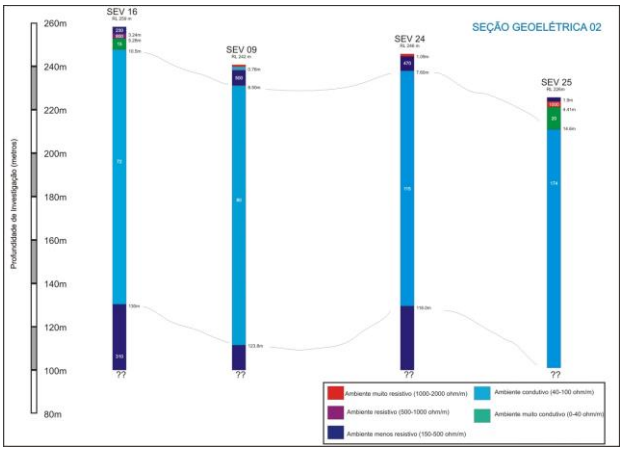

Figure 09 - Profile 01 - North Portion PA Martin Pescador.

The geo-electric section 03 (Figure 11) in the west to east, consists of the polls 20,18, 11 and 12, totaling 11.3 km of horizontal extension. Located in different geological environments (see geological map), which was also observed in the resistivity data. In these VES is observed which corresponds to the initial layer of soil coverage ranging from 2 to 8 meters, which generally have resistive character. The VES 20:18 has a low resistivity layer (32 ohm / m) ranging from 10 to 23m thick, and may be associated directly observed near the pelitic sediments VES (Figure 10). The third layer is a thick sedimentary, conductive (50-150 ohm / s) which may be associated with the interleaved Pimenta Bueno sediment formation.

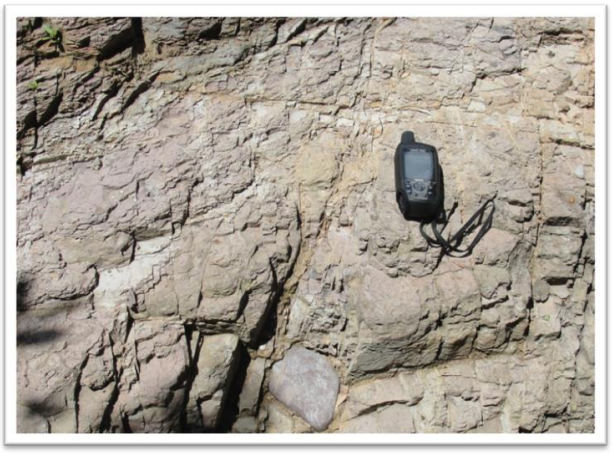

Figure 10 - North Portion PA Martin Pescador.

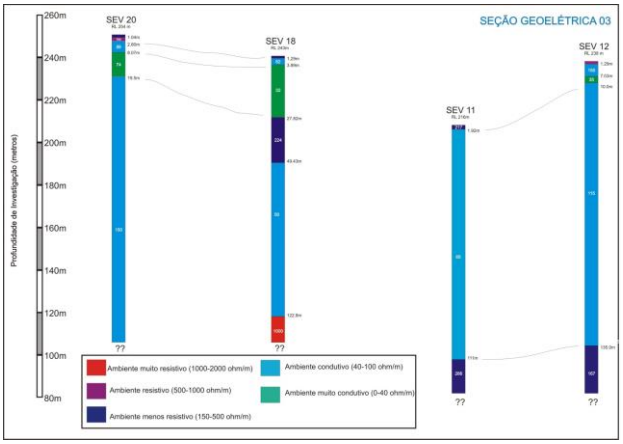

Figure 11 - Profile 01 - North Portion PA Martin Pescador.

Conclusions

The area of search has not given any hydro-geological context as a geophysicist, which already justifies the investment in this type of research. This lack of data compromises a little calibration of the models set out in this work. The data acquired in this work are efficient to estimate the thickness of geological units in the area, and the knowledge base for new underground water potential of research as well as the definition of favorable locations for capturing this resource. In a basis for making the appropriate government decisions.

The main geo-electric model consists of 04 layers:

(1) corresponding horizon bit thicker the mulch;

(2) geo-electric Extract with resistivity ranging 230-350 ohms / m is the beginning of the water aquifer, with an average thickness ranging from 4.20m to 5.00m

(3) Layer geo-electrical low resistivity ranging between 20 and 40 ohms / m, 6 to 12m thickness, such that the limit of 12 to 18 m deep.

(4) geo-electric layer, the resistivity variation 50-140 ohm / m, thick, related to the interleaved packet sediment formation Pimenta Bueno.

The surface sediments that make up the mantle Regolithic form during the rainy season intermittent aquifer, which are observed in ponds / productive dug wells during this time of year. During the dry season the water level low drastically, most of the time some (dry). The thickness of this layer is variable thickness of 5m to 18m.

In forming Pimenta Bueno, facies interleaved, corresponds to a conducive environment, but it is not established as a deep aquifer sediment, it presents an interleaved pelitic nature, very cohesive, which reduces the porosity of the sludge, favoring a low potential hydrogeological to drive. However, this same grain cohesion aspect connotes a hard rock which makes possible the formation of the fissure aquifer, which is the principal means of transmitting ground water in the area of research.

In outcrops observed in research finding was preferred billing towards azimuth 315 ° azimuth and 60, and the conjugate pair and open fractures. Form cogenéticos gasket sets of families, which has a higher sales density. Also according to data collected in the field, apparently there is a level of shallow fracturing, checking on wells drilled information to a depth of 50m.

The deep wells observed in the data acquisition stage have, in general, good productivity, which could be better used, more for it is necessary to conduct pumping tests to find the real potential of the wells in question that possibly available and a suitable reservoir of larger capacity would serve a greater number of families. Example potential is underutilized which belongs to the well ASSPRUMAP, where the depth of installation of the pump, according to local information, is a possible height may be repositioned or replaced with larger capacity, favoring the exploitation of a higher amount of water.

The total thickness of the sedimentary packets based on inversion of the sampling data exceeds 150m. The geo - electric conductive horizon (40-150 ohm / m) is the thickest layer , varying from 50m to 140m thick. Observed in the northern and central portion of the PA Martin Pescador .

Surveys on training Round Stone (C1pr) have a layer of low resistivity (20 ohm / m) with thickness ranging around 35m , sotoposta sediment training Pimenta Bueno .

In the southern part of the area VES 21:22 have a depth of approximately 130m , a geo -electric horizon high resistivity. This resistive environment may be related to another type of rock or the basement topography .

Acknowledgments

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References

CAMPOS, J.C.V.; SOUSA, R.S.; MORAIS, P.R.C. Avaliação do Potencial Hidrogeológico da Área Urbana do Município de Campo Novo de Rondônia. Relatório Técnico/CPRM. Porto Velho, 1999.

Companhia de Pesquisa de Recursos Minerais. Geologia e recursos minerais do Estado de Rondônia: Sistema de Informações Geográficas (SIG): Texto Explicativo do Mapa Geológico e de Recursos Minerais do Estado de Rondônia/Organizado por Marcos Luiz do Espírito Santo Quadros & Gilmar José Rizzotto. – Escala 1:1.000.000. Porto Velho: CPRM, 2007. 153p.: (il.).

Companhia de Pesquisa de Recursos Minerais. Mapa de Domínios Hidrogeológicos do Brasil. Escala 1:2.500.000. Coordenador do Projeto: Luiz Fernando Costa Bomfim. 2005.

Companhia de Pesquisa de Recursos Minerais. Sistema de Informações de Águas Subterrâneas (SIAGAS). Versão 2.3 MODDAD: Entrada de dados. 2009.

GEOTOMO SOFTWARE. 2003. Disponível em <http://www.geotomo.com>. Acesso em 26 de março de 2013.

ISOTTA, C.A.L.; CARNEIRO, J.M.; KATO, H.T.; BARROS, R.J.L. Projeto provincia Estanifera de Rondonia. Relatorio Final. Porto Velho: CPRM, 1978. 16v., il. (Convenio DNPM/CPRM).

TELFORD W.M., GELDART L.P., SHERIFF, R.E. & KEYS D.A. 1990. Applied Geophysics. 2nd edition, Cambridge, Cambridge University Press, 770 p.

WARD, S.H. Resistivity and induced polarization methods. In: WARD, S.H. (Ed.). Geothecnical and environmental geophysics. Tulsa: Society of Geophysicists, 1990. v.1, p. 147-190.