Preliminary geometric model of the Barreiras Aquifer derived from hydrogeophysics data at the River Catu basin, NE Brazil.

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Abstract

This work presents a synthesis of the preliminary results obtained in studies involving data integration of hydrogeophysical of the “Barreiras” Aquifer, area of the River Catu Basin, eastern coast of the Rio Grande do Norte State. The general methodology is the use of electric geophysical methods, particularly electrical resistivity, besides well lithologic profiles. In our survey, the vertical electric sounding-SEV technique has been used to determinate the saturated thickness. A preliminary map of the geometry of the Aquifer was obtained from the interpolation of the results of those SEVs and information from the available well profiles. We found out that the biggest thickness areas were notably on the oriental sector of this basin (up 90 meters thickness). These places show greater hydrogeological potentials, turning themselves into points from future exploring. Additionally, the map suggests a tectonic-structural control of the aquifer geometry, as the inferred alignments NE and NW and preferential directions similar of this regional organization previously characterized.

Introduction

This work integrates a hydrogeological and geophysical research developed in the area of the “Barreiras” Aquifer within the River Catu basin, southern coastal region of the Rio Grande do Norte State, covering part of the cities of Canguaretama, Goianinha, Tibau do Sul and Vila Flor (Fig.1). The main goal of this research is to evaluate the hydrogeological potential and natural vulnerability of the aquifer.

In this context, the main objective of the survey is to elaborate a preliminary local model of geometry of the Barreiras Aquifer, using the data of vertical electrical sounding-SEVs and the lithology well profiles. The use of geoelectrical survey has shown to be fundamental, as the well data that sectionate all the geological formation homonym of the aquifer was meager. The SEVs made possible, not only punctual values of the saturated thickness, but the achieving of the additional information, as the depth of the freatic level, non-saturated thickness and values of electrical resistivity of the main hydrostratigraphical horizons. These results will subside, in last analysis, the adding of the hydrogeophysical characterization of the Barreiras Aquifer, at the east coast of the Rio Grande do Norte State.

The Barreiras Aquifer is responsible by the water supply of around 80% of the cities and rural communities within the region, including Natal (capital of the State). The Barreiras Aquifer is also responsible for irrigation of the cultivated perimeters. Therefore, there is an increasing demand for research in this area. Its lithology is very diversified, involving from claystone to conglomeratic sandstone, with predominance of the clayish sandstone of Tertiary-Quaternary age. This sequences are caped by recent Quaternary sediments represented by sandy hedges, dunes, mudslides and wetlands (Bezerra, 1998; Lucena *et al*., 2006). The lower limit of this aquifer is the top of the non-outcropping Mesozoic carbonated sequence of the region, which has been individualized in well drilling as being composed by sandy argillite to argilitic of calciferous composition and low hydrogeological potential. The aquifer yields high flows of exploitation in some locations, especially in those of the highest thickness of the sediments of the Barreiras Formation, as observed in some exploiting at the south region of Natal and Parnamirim-RN (yielding around 100m³/h).

Regarding the hydrodynamic condition, the Barreiras Aquifer behaves in a variable way, particularly at the south region of Natal to the frontier with Paraíba State. However, the behavior varies of free to semi-confined is predominant. In this case, the semi-confining layer is at the top and is represented by clayish lens of the Barreiras Formation (IPT, 1982). All the surveyed area, has a interplay between superficial and underground springs of the Barreiras Aquifer (Lucena et al., 2004). The perennial regime of the local fluvial channels is believed to influence the Aquifer (base flow of the fluvial channels in periods of regional reduced rainfall).

The regional structural context, characterized by Bezerra et al (2001), Nogueira et al. (2006) and Rossetti et al.(2011), it’s shown preponderant in the geometry configuration of the Barreiras Aquifer in other areas of the east coast of the state. This fact that comes from the association of brittle structures and saturated thicknesses reflects on the hydrogeological potentialities, occasionally supplanting in importance the other hydrogeological parameters, as the hydraulic conductance and the storage coefficient (Lucena et al., 2006).

Method

Traditionally the electric resistivity method has been used in hydrogeologic surveys (Astier, 1975; Custódio e Llamas, 1983; Feitosa et al., 2008). It consists in the determination of the electric resistivity of rocks by measuring electric potential and current, being these values o resistivity variable in respect to the porosity, quantity and salinity of the interstitial fluids. This observation took to the broadcast use of an empiric relation known as Archie's Law (*in* Orellana, 1972). In this survey, a resistivimeter model Geotest RD-300b (Geotest – Indústria e Comércio de Equipamentos Eletrônicos Ltda.) was used. This apparatus minimizes the instability of the readings, because of the polarization on the electrodes phenomena, in addition to make an electronic filtering on the signal, reducing noises from telluric currents and transmission lines. Noises that were made by possible electromagnetic inductions were controlled by maintaining adequate distance between the cables of reception and transmission. Between the modalities of geoelectric investigation and according with the proposed objectives, it was chosen the vertical electric sounding-SEV, with a Schlumberger arrange for the electrodes. This technique makes possible the characterization of the variations of the resistivity in respect to the depth, since it's valid for the area a model of plane and parallel layers. In this aspect, the geoelectric model adopted may be summarized according to the following characteristics (Orellana, 1972):

i - The underground is made by a sequence of layers with thicknesses (E_i) finites, but the last which is made as infinite.

Ii - Each layer is assumed as electrically homogeneous and isotropic, being characterized by a resisitivity (ρ_i);

Iii - The interfaces of separation between the layers are plane and horizontal and parallel to the surface of the earth.

Additionally, a geoelectric calibration was made, being made of a SEV executed adjacent to a well of lithologic profile known (Lucena, 2005), aiming to minimize the ambiguity of the method, particularly the geoelectric equivalences (Fig. 2). The interpretation of the field data were realized with the software WINSEV (W-Geosoft), that ultimately provide models of "electric resistivity x thicknesses", making possible the identification of punctual values of saturated thicknesses. These data have been added to those of known wells of the area and that cross cut all the Barreiras Aquifer, allowing the elaboration of a map of saturated thickness, using interpolation and gridding of these.

Results

There were been realized 15 vertical electric soundings in the area, which evidenced values of resistivity of the saturated zone between 40 to 900 Ohm.m, for claystone layers and sandstone layers respectively. The stratigraphic horizons with the biggest hydraulic conductance, however, present resistivity greater than 250 ohm.m. The hydrogeologic basement of the aquifer presented values of electric resistivity of 70 Ohm.m. This basement is associated with the top of the carbonate Mesozoic non outcropping sequence, as reported and based on lithologic well profiles and is represented lithologically by sandstones to calciferous claystones.

The table 1 presents the vertical electric sounding executed, with information of the UTM coordinates and its saturated thicknesses, by example of 5 tubular wells that sectionate all the Barreiras Formation and its aquifer.

Table 1. defined saturated thicknesses information in interpretations of SEVs and wells at the area of the River Catu Basin.

SEV´s	UTM		SATURATED THICKNESS
	X	Y	
SEV 01	259948	9296646	43,3
SEV 03	257278	9298415	21,5
SEV 04	262757	9297930	64,1
SEV 05	260539	9308256	92,9
SEV 06	266251	9310920	21,2
SEV 07	269823	9310928	40,1
SEV 08	268370	9310058	79,9
SEV 09	270330	9304236	62,6
SEV 10	268304	9303375	77,7
SEV 11	266500	9301640	68,9
SEV 12	263523	9300966	34,8
SEV 13	260812	9303524	51,95
SEV 14	262745	9306840	41,4
SEV 15	265875	9307718	42,8
SEV 16	267062	9308822	93,7
Pt 01	265282	9302766	44,72
Pt 02	262228	9295730	45,92
Pt 03	270137	9301274	64,43
Pt 04	271340	9307145	61,59
Pt 05	262300	9308400	46

The interpretation and mathematical modeling of the SEVs, in addition to the well data, have made possible the elaboration of a preliminary map of thickness of the Barreiras Aquifer at the area of the River Catu Basin (Fig. 3). This map, despite representating the results of the interpolation and gridding of punctual data ("XY" coordinates and its respective saturated thicknesses "Z"), can be considerate as preliminary representative of the local behavior of the geometry of the aquifer in study. The analysis of the map reveals values of saturated thicknesses superior to 70m in almost all its oriental sector and extreme northwest, while the Southwest quadrant reveal values inferior to 40m. The dashed lines at the map, particularly, were inferred considerating approximated limits between positive and negative anomalies of saturated thicknesses and/or continuity of isolines. The NE and NW directions of those alignments are coincide with the two main directions of the predominant regional structure at the east coast of Rio Grande do Norte, as research of Bezerra et al (2001), Nogueira et al. (2006) e Rossetti et al. (2011). That fact, although requiring, between others aspects, the identification and characterization of underground rejects and associated surface features, suggests the strong influence of this regional structure in the geometrical

aspect of the Barreiras Aquifer in the area, such as research realized in side areas (Lucena et al., 2006).

Conclusions

The application of shallow geophysical methods, particularly the electric resistivity method, has shown itself as fundamental tool as an aid to the characterization and development of a conceptual model of the Barreiras Aquifer in the area of River Catu basin-RN. This survey has elevated itself in importance as the availability of information of tubular wells profiles at the region is much reduced, above all, about the thicknesses of all the Barreiras Formation and its aquifer. The map of saturated thickness has evidenced a substantial variation of those values through all the surveyed area, those thicknesses from 20 to 30 meters at the extreme SW and up to 90 meters at the oriental sector and extreme NW. This geometric configuration seems to reflect the influence of the regional structure in the hydrogeologic context, judging preliminary by the match between alignments inferred in the map of saturated thickness e the main directions of the regional structure. The results of this survey are more important as it presents an immediate applicability, as the identification of more promising zones in terms of hydrogeologic potential and, therefore, priority locals for future exploitation.

Acknowledgments

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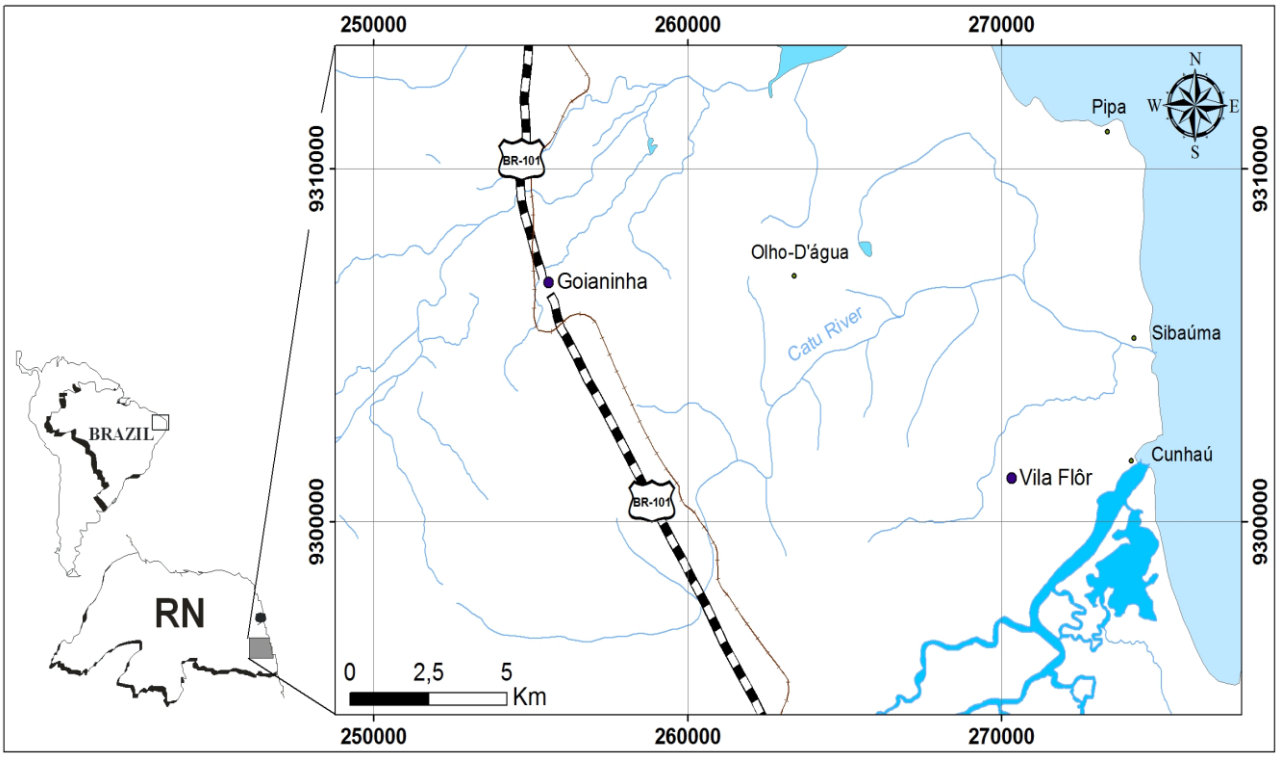

Fig.1 - Area of the "Barreiras" Aquifer within the River Catu basin.

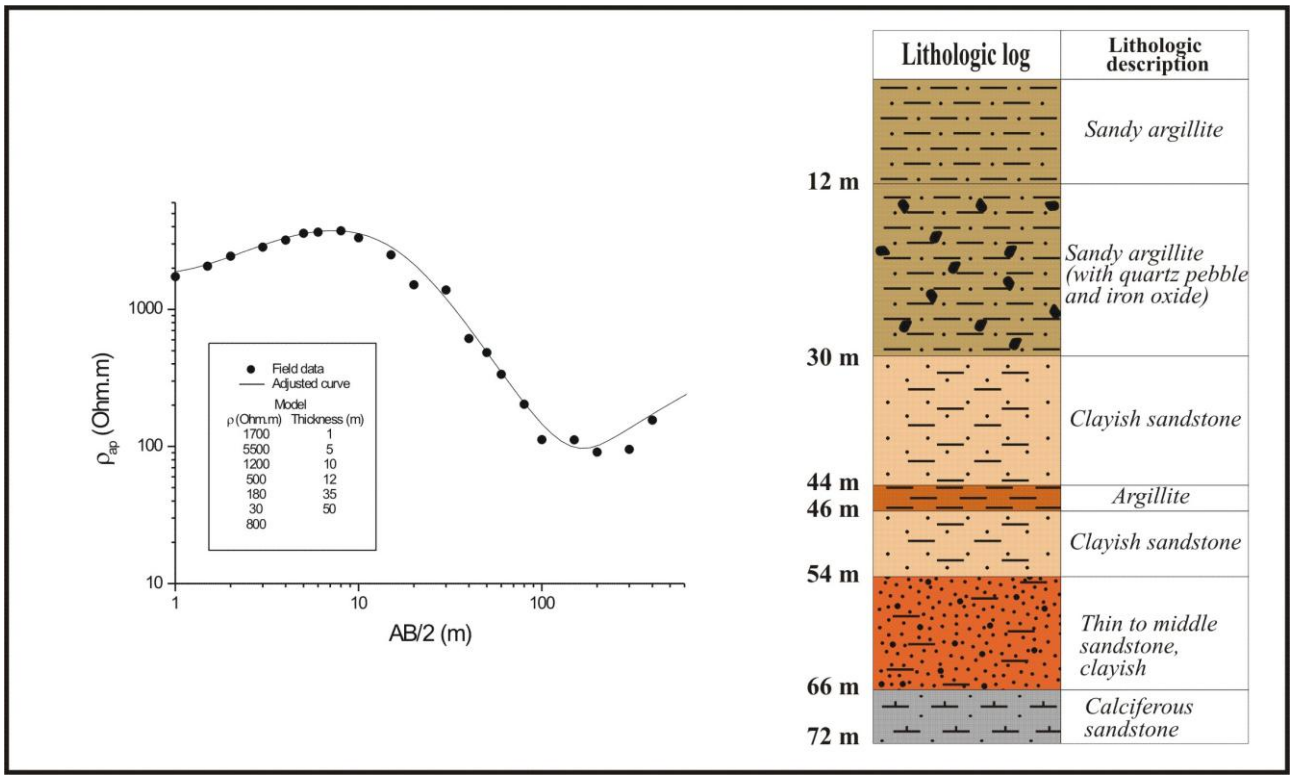

Fig.2. Geoelectric calibration at Barreiras Aquifer (Lucena et al., 2005).

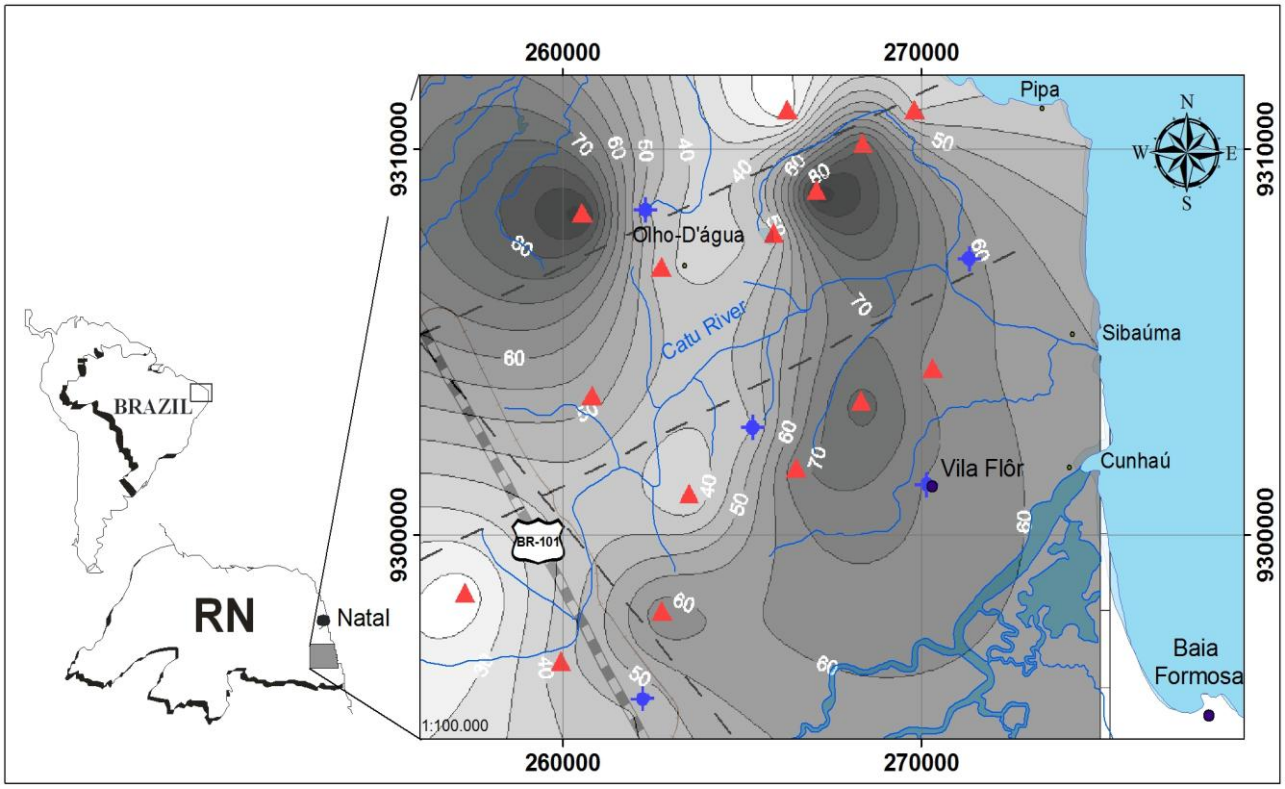

Fig.3 - Preliminary map of thickness of the Barreiras Aquifer at the area of the River Catu Basin.