The Use of Shallow Geophysics in Borrow Clayey Deposits Surveys in NorthEast Brazil

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Abstract

There is an increasing need for clayey material for the construction of mineral clayey liners in hazardous waste landfills due to fast growth of the Brazilian economy evidenced in the past few years. Since the great majority of the Brazilian industrial activity is concentrated along the Atlantic Ocean shore, there is a growing interest in the use of materials from the Barreiras Formation for this purpose. Assessing clayey subsurface deposits in the Barreiras Formation is not an easy task since different types of materials are present in small depths. Their layers are not continuous and do not show the same thickness. The methodology presented and the results shown in this paper shows that is possible to couple borehole drilling with geophysics to overcome this difficulty. It was also revealed the benefits of using geostatistics in generating sections that could be compared to the results of geophysical surveys ratifying or rectifying the geological conceptual model.

Introduction

The fast growth of the Brazilian economy evidenced in the past few years has lead to an increasing demand for hazardous waste landfills, especially in the oil and aluminum industries. These facilities uses huge amount of clayey soils to build mineral impermeable liners to avoid the transport of hazardous pollutants to the environment. Since the great majority of the Brazilian industrial activity is concentrated along the Atlantic Ocean shore, there is a growing interest in the use of materials from the Barreiras Formation for this purpose.

Traditionally, the statigraphy of the near surface of the Barreiras Formation is determined through the use of direct survey investigation (*i.e.*, borehole logging employing augers, hollow augers and hydraulic boring machines). However, due to its heterogeneity, most of the investigations carried out so far resulted in failure.

In order to overcome this inconvenience it was proposed to combine the use of direct survey to indirect methods like shallow geophysical and geostatistics. This paper presents the study conducted at the city of São Sebastião do Passé, in the Recôncavo Baiano, aimed on distinguishing the different material layers in order to establish their subsurface location and volume. Figure 1 shows the location of São Sebastião do Passé

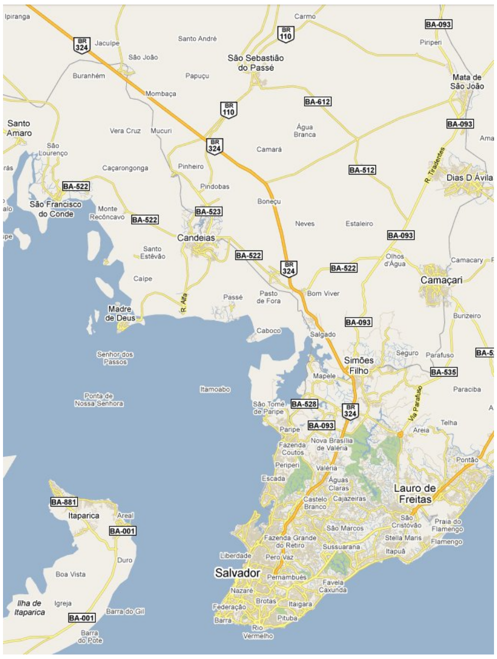

Fig. 1 – State of Bahia showing the location of São Sebastião do Passé.

Materials and Methods

Direct Survey Investigations

The direct investigations were performed with the use of manual augers. Initially, five boreholes (*e.g.*, SD01, SD02, SD03, SD04 and SD05) were drilled to a maximum depth of 6 meters, in each of them the water level was determined by the use of a Solinst water level detector. The materials collected in each borehole were identified using the procedure specified by ASTM D2488 (2009). The geographical position of each borehole and its associated water level was identified by the use of a PROMARK II geodetic gps system. These pieces of information were used to establish the local groundwater flow gradient and direction. Based on these pieces of information, four additional boreholes (*e.g.*, PM01, PM02, PM03, PM04 and PM05) were drilled to a same depth to aid in the design of a conceptual geological model of the site. The topographic map and distribution of the boreholes in the study area are presented in Figure 2.

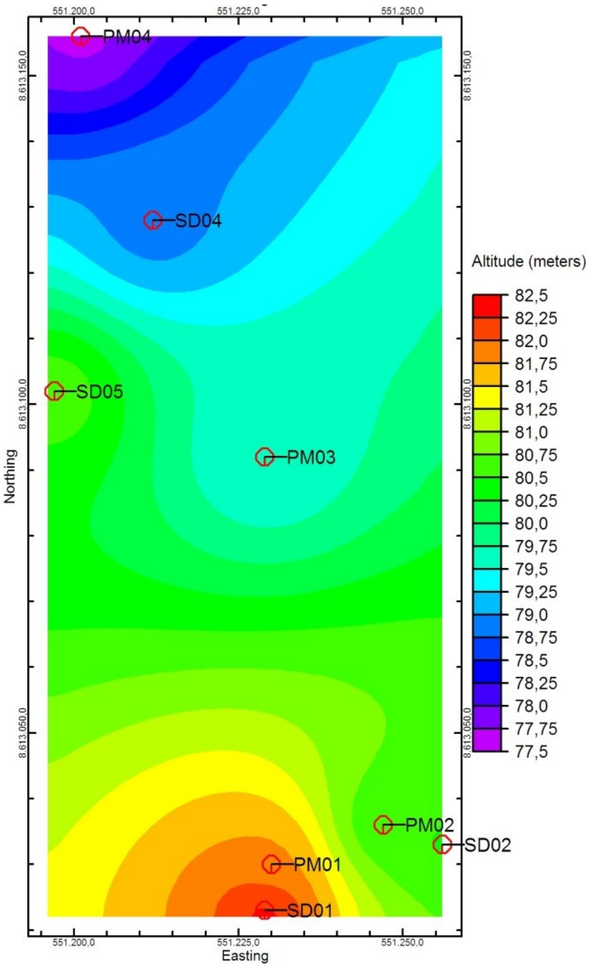

Fig 2 – Topographic map and distribution of boreholes in the study area.

Geophysical Investigation

The shallow geophysical survey was performed using a ground penetrating radar (GPR) MALA, model RAMAC. The equipment, seen on Figure 3, consists of a unit control cased in a backpack where the emitted and received electromagnetic waves signals are transferred to a monitor that enables the visualization of the radargrams.

The survey positioning was achieved by the use of a hipchain oedometer that can be seen at the waist of the operator in Figure 3. Additionally, a gps unit was linked to the unit control using a NIMEA protocol, enabling the visualization in satellite images through the use of the software GPS Mapper®.

Fig 3 – GPR system employed in the survey.

The survey was performed using 100 MHz Rough Terrain Antennas(RTA's) seen in Figure 4. The central frequency of the antenna was chosen following the indications given by Porsani (1999) e Annan & Cosway (1992).

Fig 4 –Rough Terrain Antenna employed in the survey

GPR data acquisition was accomplished by the use of the software GroundVision®. For most of the profiles, the following parameters were adopted:

- Number of scans – 768;
- Number of stacks – automatic;
- Range– 204,8ns;
- Scan interval – 0,10m;
- No filtering.

The acquired data were processed via the software RadExplorer®. All radargrams were processed using the same processing resources. Firstly, the delay of the direct wave was adjusted to the zero position and, just after that, the data were filtered with a vertical filter, IIR filter, to delineate the frequency range for the used antenna. An automatic gain function (AGC/SEC) of 10 points was used. At the end, skipping was used to better adjust the visualization of the radargrams.

Results

The results of the augering drilling process in the nine boreholes are shown in Figure 5. This figure shows that five types of soils are present in the subsurface: a brown sandy clay, a reddish grey clay, a yellowish grey sandy clay, a grey clay and a green clay. This same figure also shows that the thickness of each layer varies in space.

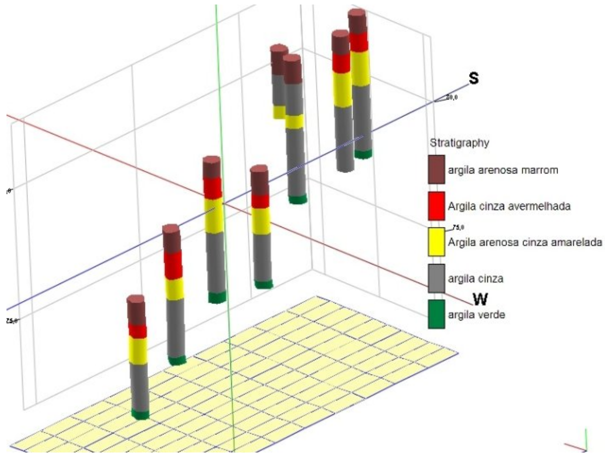

Fig 5 – Stratigraphy *of the boreholes.*

The shallow geophysics using GPR was employed to verify the spatial distribution of the materials encountered during drilling. The aim was to observe the variation in thickness of each layer between the drilled boreholes.

The comparisons were performed section by section using geostatistics software to generate the sections from the drilling data obtained from the boreholes and the radargrams from the GPR. Sections were obtained employing the software Rockworks® using the inverse of the distance method of interpolation.

The results shown in Figures 6 and 7 shows a good agreement between the sections obtained from the results of augering drilling and geophysical survey.

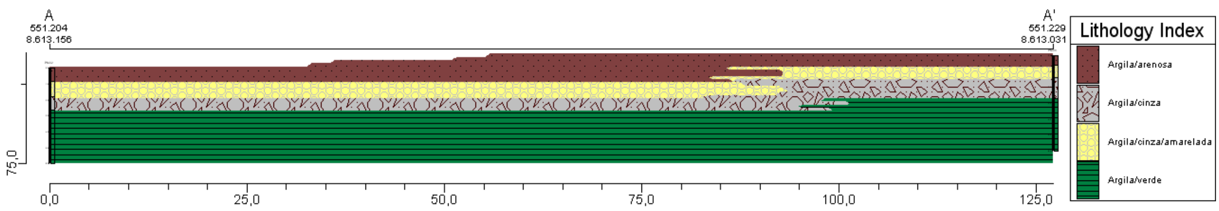

Fig 6 – Section of the site obtained from augering drilling

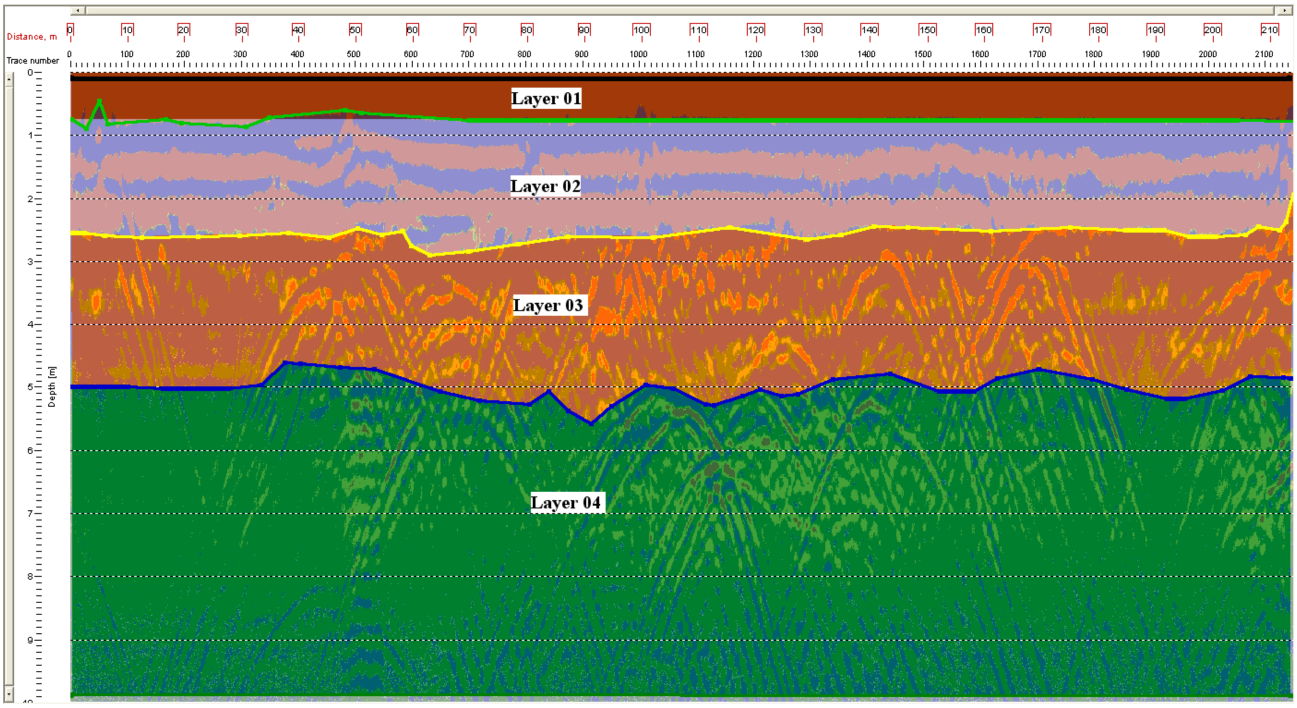

Fig 7 – Radargram of the same section of Figure 6

Based on the good agreement between the results of augering drilling and geophysics it was possible to develop the geological conceptual site model shown in Figures 8 and 9.

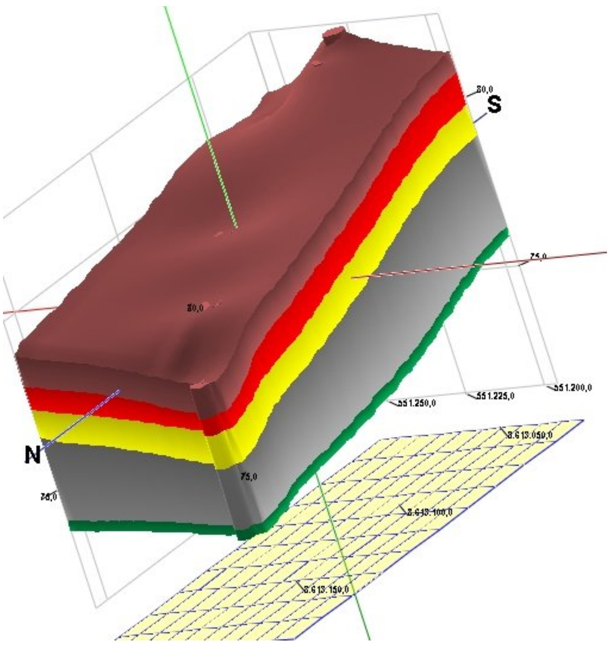

Fig 8 – Stratigraphy digital model 01.

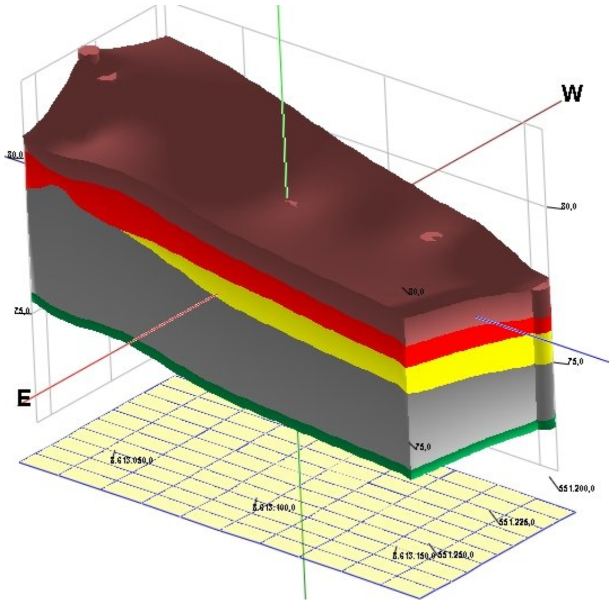

Fig 9 – Stratigraphy digital model 02.

The geological model indicates that the yellowish grey sandy clay is not continuous in the entire site and the thickness of the grey clay, the material that could be used in the mineral barrier liner, also varies.

Based on this model, it was possible to evaluate the amount of the grey clay presented in this site and indicate the best method to excavate it considering the water level.

Conclusions

Assessing clayey subsurface deposits in the Barreiras Formation is not an easy task since different types of materials are present in small depths. Their layers are not continuous and do not show the same thickness.

The methodology presented and the results shown in this paper shows that is possible to couple borehole drilling with geophysics to overcome this difficulty. It was also revealed the benefits of using geostatistics in generating sections that could be compared to the results of geophysical surveys ratifying or rectifying the geological conceptual model.

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