# STUDY OF SUBSURFACE CONTAMINATION BY HYDROCARBONS AT GAS AND OIL STATIONS IN THE CITY OF BRAGANÇA (BRAZIL)

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## ABSTRACT

In the state of Pará (Brazil), there exist 948 registered posts of combustibles. These establishments turned out to be the principal causes of contamination of the environment mainly through the emptying of combustibles (gasoline, alcohol, and diesel), due to the corrosion and cracks in tanks and tubing. In Bragança city (Pará, Brazil) is common to find Gas and Oil Stations and little is known about the possible risks that these posts can cause to the soil and groundwater of this city. For the majority, these posts were constructed in the 1970s and 1980s, which causes serious problems due to the fact that these subterranean storage tanks have a median life of up to 25 years. In this paper seeks to characterize the spatial distribution of possible plumes of hydrocarbons, in function of geological, hydrogeological and geophysical aspects of the Gas and Oil Stations located in Bragança city, Pará, based on the Ground Penetrating Radar (GPR) data and modeling tool. This application is a of great relevance seeing as those it is the first of this kind in this city and aiming to prove the efficiency of the method and propose monitoring and correcting measures of the contaminated areas.

## INTRODUCTION

The contamination of the soil and groundwater is a worrying factor that could cause diverse problems for human health and cause unrepairable damage to the environment.

In Brazil, between the years 2002 and 2012, an existence of almost 39,027 of registered stations were noted, a production of approximately 2, 137 barrels per day of crude and a consumption rate of 2,604 barrels per day. In the state of Pará (Brazil), there exist 948 registered stations of combustibles (ANP, 2012). These establishments turned out to be the principal causes of contamination of the environment mainly through the emptying of combustibles (gasoline, alcohol, and diesel), due to the corrosion and cracks in tanks and tubing.

In Bragança, located in the northeastern part of the state of Pará (Brazil), it is common to find stations of combustible and little is known about the possible risks that these stations can cause to the soil and groundwater of this city. For the majority, these stations were constructed in the 1970s and 1980s, which causes serious problems due to the fact that these subterranean storage tanks have a median life of up to 25 years and according to international statistics, tanks older than 20 years old are more prone to problems due to corrosion and cracks (BLACKMAN, 1996; PENNER, 2000; SILVA, 2002).

The geophysical methods can help us in the detection of plume contamination and represent the best solutions to the problem (SOARES, 2007), permuting the quick delimitation in the continuous lateral distribution and the depth of plume contamination (COSTA et al., 1999).

In this paper seeks to characterize the spatial distribution of possible plumes of hydrocarbons, in function of geological, hydrogeological and geophysical aspects of the combustible stations located in Bragança city, Pará, based on the Ground Penetrating Radar (GPR) data and modeling tool. This application is a of great relevance seeing as those it is the first of this kind in this city and aiming to prove the efficiency of the method and propose monitoring and correcting measures of the contaminated areas.

## AREA OF STUDY

The area of study is located in the Bragança city, in the state of Pará. It is geographically located at the latitude 1º 03’ 57.43’’ South and longitude 46º 47’22.24” West (Figure 1).

## METHODOLOGY

### DATA ACQUISITION

The geophysical data (GPR data) was collected with the GSSI SIR3000 equipment and an antenna with the frequency of 400 MHz and the temporal window at 50 ns (nanoseconds). The use of the temporal window depends greatly on the depth of interest in the study, which varies according to the objective. The source-receptor configuration considered in this data was the Common-Offset with a monostatic arrangement, where an antenna emits and receives an electromagnetic signal. This arrangement setting was chosen in function with the capability of the instrument. For each line acquisition sampling was performed in 5 of 5 meters and the spacing between lines was considered 10 meters, respectively. The collections were taken in the dry period of the year 2011 (month of November) and in the rainy period of 2012 (month of March).

For this acquisition, the six supply stations in the city were: Ajuruteaua 1 (P01); Ajuruteua 2 - (P02); Ajuruteua 3 - (P03); Bragantino - (P04); Bom Jesus - (P05) and Rodoterra - (P06), respectively (Figure 1). The selection depended on the availability of the stations for acquisition. The location and the direction of the profile of GPR data of the six stations collected were determined by the stations available.

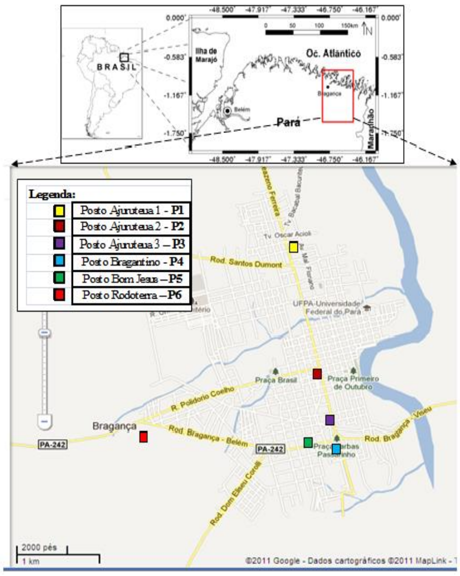


*Figura 1. Area of study showing the combustible stations in the Bragança city (Pará, Brazil).*

The Ground Penetrating Radar (GPR) method

The GPR is an electromagnetic method based on the propagation of electromagnetic waves (EM) of high frequency (10 MHz - 2.5 GHz) in one medium, i.e., based on the emission, reflection and reception of the wave, which responds to the dielectric properties of the earth, in which the signal- the electromagnetic wave -is propagated. The method provides a quality imaging of the underground, to be capable of characterizing, localizing and mapping structures and identify geological structures of an efficient form (PORSANI, 2008).

MODEL

For the modeling and 3-D visualization of the subsurface we considered the six stations in the city of Bragança, Pará-Brazil, previously cited. We created structural and stratigraphic models with the data collected in these stations, in order to take into consideration the complexity of subsurface geology in the area studied.

## RESULTS

After the GPR data was collected, processed, and interpreted the study proceeded to build the geological models for each one of the combustible supply stations. The presented results are to characterize to the spatial distribution at the surface level, in function with the geological, hydrogeological, and geophysics aspects of the referenced stations. As noted in Figures 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12, the 3-D visuals reflect the structural models and stratigraphic of the six stations analyzed.

## CONCLUSIONS

The geophysical tools utilized in this study (GPR and modeling) allowed for the characterization of the problem of the possible contamination for hydrocarbons of the superficial level of the stations, with this spatial distribution the contamination was detected. It can be verified through the geophysical studies (GPR electromagnetic method) in which five stations represent zones registered with low levels of electromagnetic waves, which represent a possible environmental contamination through the hydrocarbons at the surface level, through the damaged tanks in these stations. These stations are: Ajuruteua 1 (P01), Ajuruteua 2 (P02), Ajuruteua 3 (P03), Posto Bom Jesus (P05) and Posto Rodoterra (P06). The only supply post that did not present zones of attenuation was the Posto Bragantino (P04).

Attention should be paid in the case that the stations represent zones of intense low reflection (01, 03 and 06 Stations). These stations are considered as possibly contaminated as they are evidently in zones showing chaotic characteristics during the reflections. The same could occur in Ajurtueua 2 (P02) Post, which is characterized as a weak low zone of reflection. Bom Jesus (P05) Post represents the zone of reflection most different than the others, possibly indicating the content of highly conductive material.

A spatial distribution was characterized at the subsurface through 3-D modeling. It was verified that the possible zones of detected contamination (represented by bodies of green color), attending to the water table in the P01 and P06 Stations. The water table is located at a depth approximately of 3 meters; presenting itself as a continuous reflector.

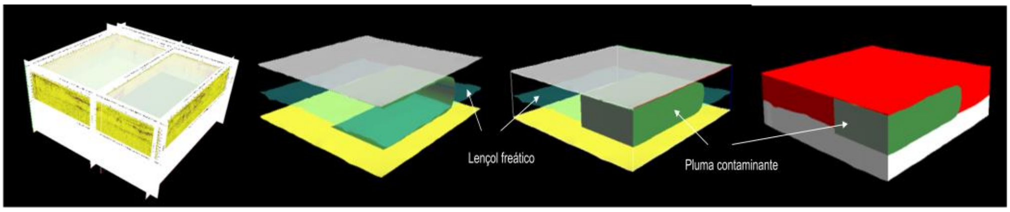


***Figure 2.*** *3-D visualization of structural and stratigraphic of subsurface models for Ajuruteua 1 Post (dry season, November 2011).*

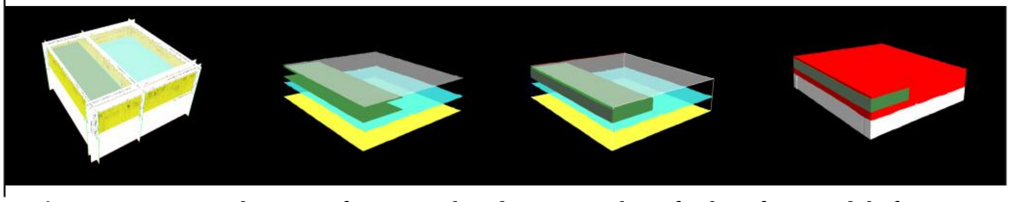

***Figure 3.*** *3-D visualization of structural and stratigraphic of subsurface models for Ajuruteua 1 Post (rainy season, November 2011).*

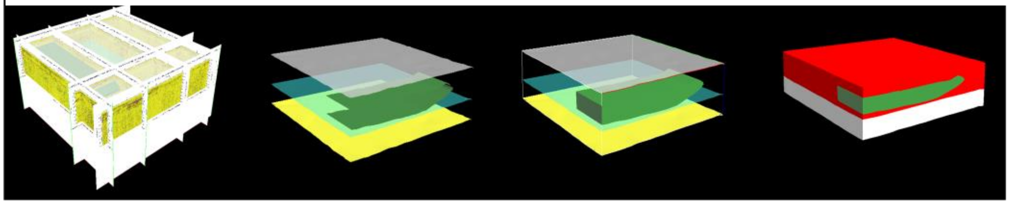

***Figure 4****. 3-D visualization of structural and stratigraphic of subsurface models for Ajuruteua 2 Post (dry season, November 2011).*

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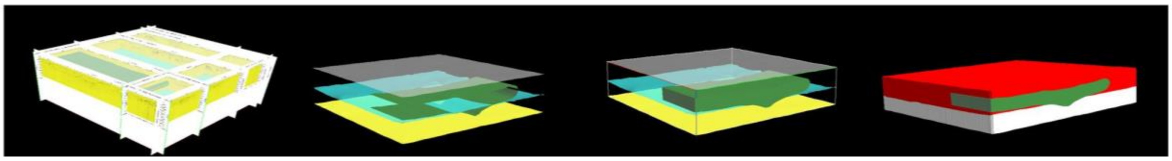

***Figure 5.*** *3-D visualization of structural and stratigraphic of subsurface models for Ajuruteua 2 Post*

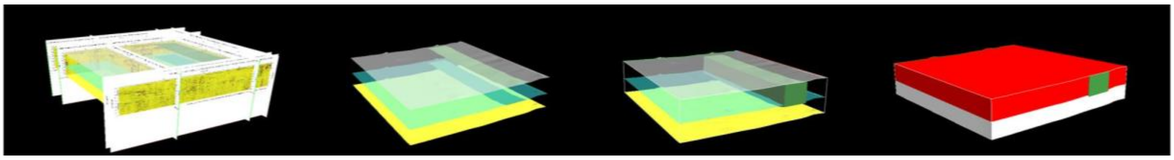

***Figure 6****. 3-D visualization of structural and stratigraphic of subsurface models for Ajuruteua 3 Post (dry*

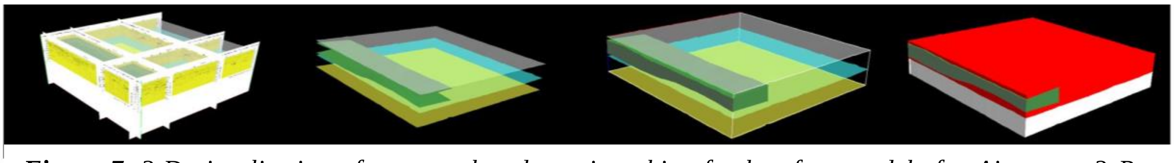

***Figure 7****. 3-D visualization of structural and stratigraphic of subsurface models for Ajuruteua 3 Post*

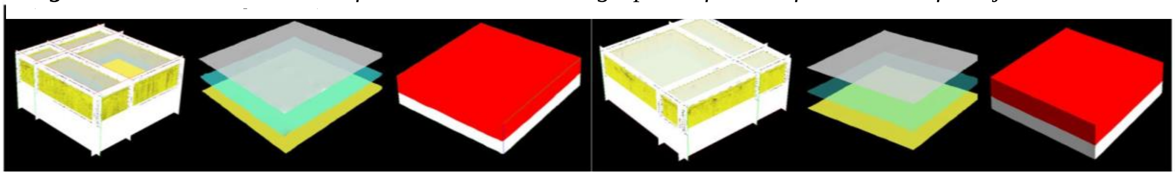

***Figure 8.*** *3-D visualization of structural and stratigraphic of subsurface models for Bragantino Post (dry*

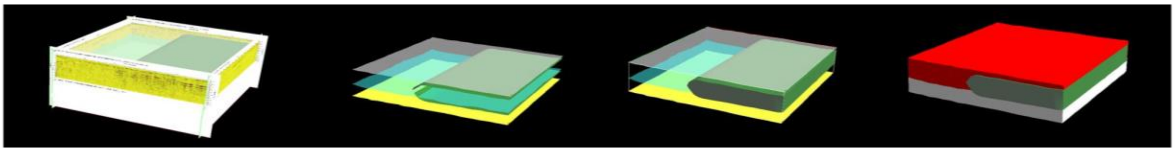

***Figure 9.*** *3-D visualization of structural and stratigraphic of subsurface models for Bom Jesus Post (dry*

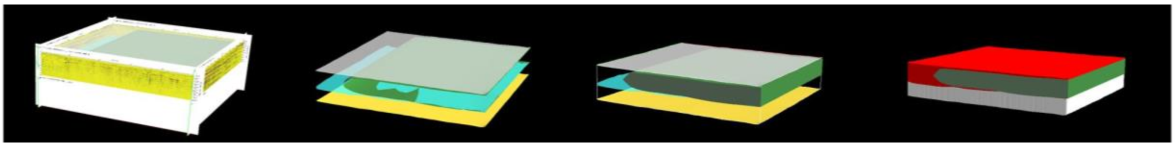

***Figure 10.*** *3-D visualization of structural and stratigraphic of subsurface models for Bom Jesus Post (rainy season, November 2012).*

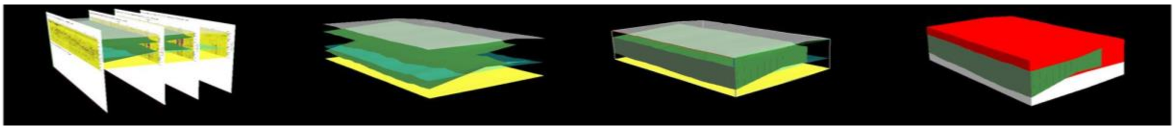

***Figure 11****. 3-D visualization of structural and stratigraphic of subsurface models for Bom Jesus Post (dry*

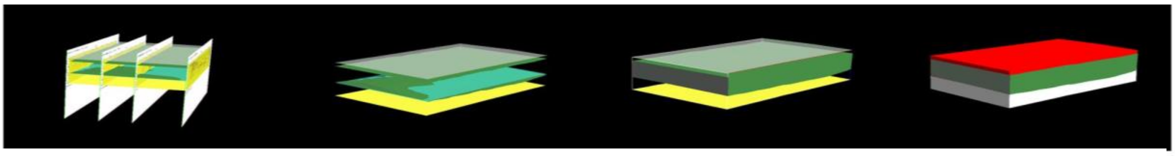

***Figure 12.*** *3-D visualization of structural and stratigraphic of subsurface models for Rodoterra Post*