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Preliminary Evaluation of Radarsat Fine Mode Image to Map Linear Features in Area of Hydrocarbon Microseepage, Tucano Basin, Brazil (GlobeSAR-2, Project Brazil - 15)

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ABSTRACT

This paper discusses preliminary results of using Radarsat fine mode image to map linear features associated with faults and fractures, which may constitute paths for the migration of hydrocarbon to the surface, in the Tucano basin, Northeastern Brazil. After speckle removal and geometric correction, visual interpretation of a linear contrast stretched image permitted to map several photogeologic lineaments concentrated in areas with hydrocarbon microseepage anomalous targets, previously identified through a geochemistry soil gas survey. It was very difficult to confirm the geologic nature of the interpreted lineaments during field check due to the widespread presence of regolith. However, in some places it was possible to confirm the presence of fractures and faults related to the lineaments. Preliminary results show that the high resolution Radarsat fine mode image is a powerful tool to map linear features related to fractures and faults, even in an area of flat topography. Structural interpretation integrated with geochemistry data, permitted to outline a preliminary model to explain the distribution of microseepage in the study area.

Introduction

The microseepage phenomenon results from the upward migration of hydrocarbon and associated fluids through the rocks overlaying oil/gas deposits, along their micro and macroscopic planes of weaknesses. Presence of faults and fractures in areas of hydrocarbon microseepage has permitted to use remote sensing data in oil/gas exploration (e. g. McCoy et. al, 1986; Pauken et al., 1986; Mello et al., 1996). The ability of radar imagery to highlight linear features makes these remote sensing data of particular interest in this kind of study.

In the present study we evaluate a high resolution Radarsat fine mode image to map lineaments (fractures and/or faults) in the region of Tonã plateau, Tucano basin, where several microseepage areas have already been identified. The term *lineament* is here used as proposed by O'Leary et al. (1976), to designate "a mappable, simple or composite linear feature of the surface, (...) which presumably reflects a subsurface phenomenon".

Study Area

The study area (Figure 1) is located in Northeastern Brazil. It has a semiarid climate with average annual precipitation under 500 mm. The vegetation is constituted by a dry savanna-like cover ("Caatinga"), characterized by small trees with profusion of thin stems and reduced number of leaves.

The Tucano basin is part of the Recôncavo-Tucano-Jatobá rift, a series of elongated half grabens, about 600 km long by 90 km wide, formed during the early stages of the South Atlantic opening in Early Cretaceous (Milani & Davison, 1988). Sedimentary sequences in the rift comprise lacustrine and deltaic shales and sandstones, followed by fluvial sandstones of the Early Cretaceous. These sequences are unconformably covered by Aptian fluvial and alluvial sandstones and siltstones of the Marizal Formation. Outcrops of these post-rift rocks in the study area consist of weathered and oxidized fine-grained quartzose whitish-to-reddish sandstones with cross-stratification and current marks. Albian (?) marine calcilutites with intercalation of cherty limestones, constitute the Tonã plateau (Almeida Filho, 1997). Either Tonã plateau or surrounding area has a flat to gentle topography, with widespread whitish to brownish sandy soils.

As part of a regional exploration program, the Brazilian Oil Co. (Petrobras) carried out a geochemistry soil gas survey in the northern part of the Tucano basin, with 633 sample points for methane, ethane, propane, butane and pentane, in a surveyed area of approximately 1,300 km² (Babinski *et al.*, 1993). Heavy hydrocarbon content (ethane to pentane) yielded an arithmetic mean value of 4.98 ppm, which was assumed as the regional background (methane was not included due to its possible biogenic origin). Figure 2 is the contour map showing the distribution of heavy hydrocarbon content (above the background level) in the study area. According to these data, several hydrocarbon microseepage anomalous targets occur mainly surrounding the Tonã plateau.

Image Processing

In this study we used an ascending Radarsat (C-band, HH polarization) fine mode image (F2), acquired on May 20th, 1997, under an incidence angle of approximately 40° and resolution of 10 meters.

In order to reduce speckle noise, several adaptive and non-adaptive despeckling filters were tested. The best results, in terms of minimum loss of textural information and preserving edges, were obtained with a gamma filter with window of 5 by 5 pixels. After reducing from 16-bit to 8-bit, the image was referenced to the Universal Transverse Mercator coordinate system, through a least squares first-degree polynomial rectification algorithm based on control points extracted from a topographic map (1:100,000 scale), yielding an accuracy equivalent to 0.7 pixel. Final enhancement of the image for visual interpretation involved the application of linear contrast stretch. As ascending orbit images show appearance of inverted topography, the image was multiplied by minus 1, in order to recover the actual topographic aspect of the area.

Data Interpretation

Figure 3 shows the contrast stretched Radarsat fine mode image of the study area (multiplied by minus 1). The Tonã plateau is the south-to-north elongated topographic feature in the western border of the image.

Interpreted lineaments, assumed as representing fractures lines and faults, are superimposed on the same image, in Figure 4. It was very difficult to confirm the geologic nature of the interpreted lineaments during field check, due to the widespread presence of regolith in the area. However, in a few places it was possible to confirm the presence of fractures and faults related to the photointerpreted lineaments.

Analysis of the radar image also permitted to identify a circular feature in central part of the Tonã plateau. Based on preliminary field data, this circular feature is probably a collapse structure resulting from the dissolution of underlain carbonate rocks in the Tonã plateau.

As showed in Figure 4, the region of the Tonã plateau has a higher density of lineament compared with the rest of the study area. Comparison with Figure 5 shows a very good spatial correspondence between the distribution of lineaments and anomalous areas of hydrocarbon microseepage. According to our interpretation these lineaments, representing fractures lines and faults, constituted the primary conduits for the migration of hydrocarbon and associated fluids to the surface.

Most of the gas soil anomalies are distributed along the border zones of the Tonã plateau. This fact suggest that the cherty limestones that constitute the plateau work as an effective seal to prevent the vertical migration of the fluids, which escaped in the contact zone with the soft sandstones of the Marizal Formation. Only one soil gas anomaly occurs over the Tonã plateau, just in the center of the circular collapsed structure mentioned previously. In this particular case, the collapse phenomenon seems to disturb the cherty limestone seal, allowing the vertical migration of the hydrocarbon in that site. These facts suggest that the hydrocarbon reservoir responsible for microseepage areas is located just under the Tonã plateau.

Conclusions

Preliminary results showed that the high resolution Radarsat fine mode image is a powerful tool to map linear features associated with fracture lines and faults, even in an area of flat topography. These features constituted paths for the migration of hydrocarbon to the surface. Structural interpretation suggests that the distribution of soil gas anomalies in the Tonã plateau conforms a combined lithologic/structural control.

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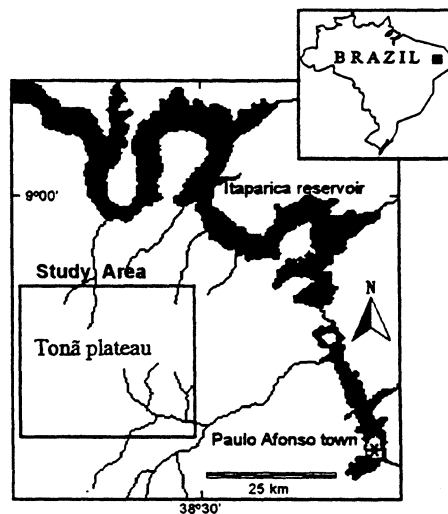


Figure 1. Location of the study area.

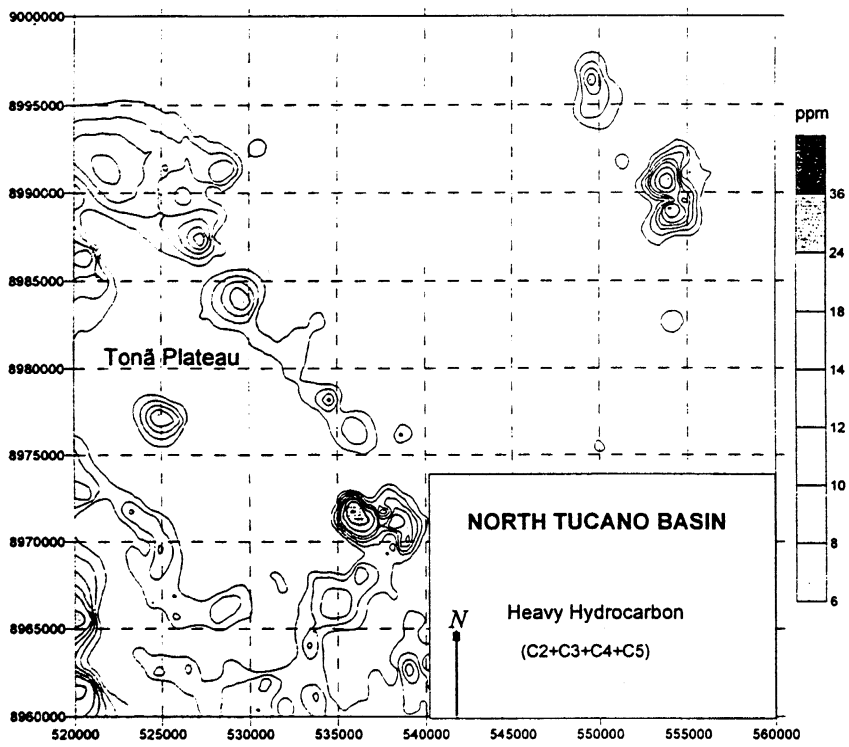


Figure 2. Contour map showing distribution of heavy hydrocarbon content in the study area.

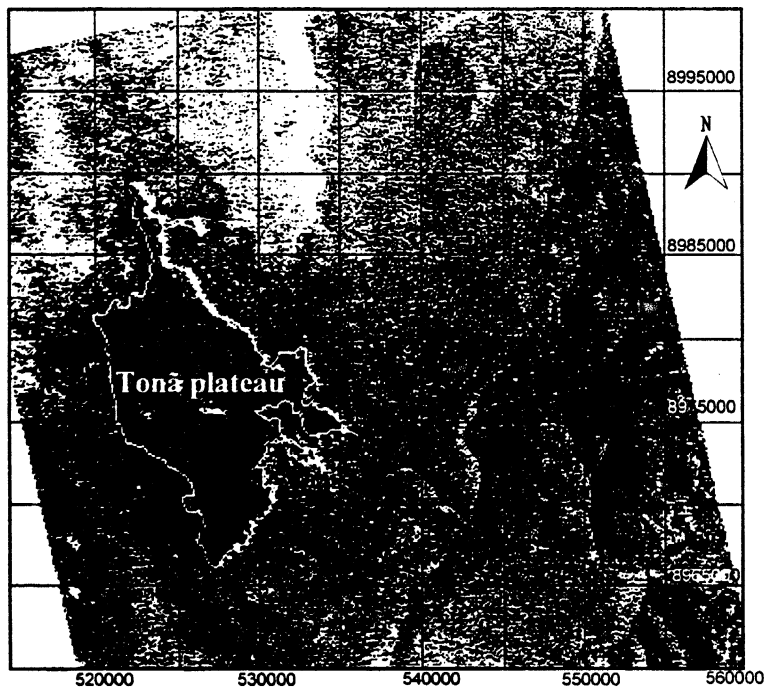


Figure 3. Contrast stretched Radarsat fine mode image (multiplied by minus 1) enhancing the Tonã plateau.

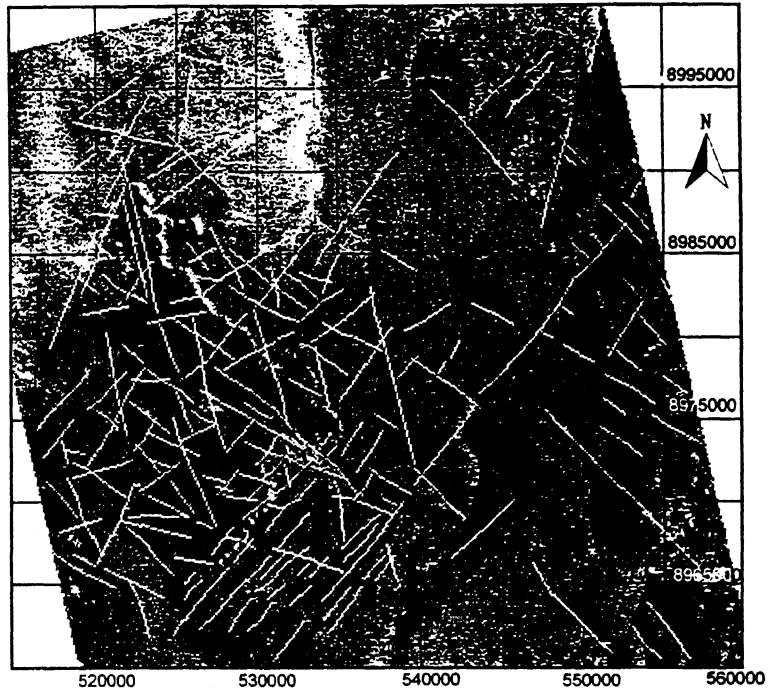


Figure 4. Radarsat image and interpreted lineaments.

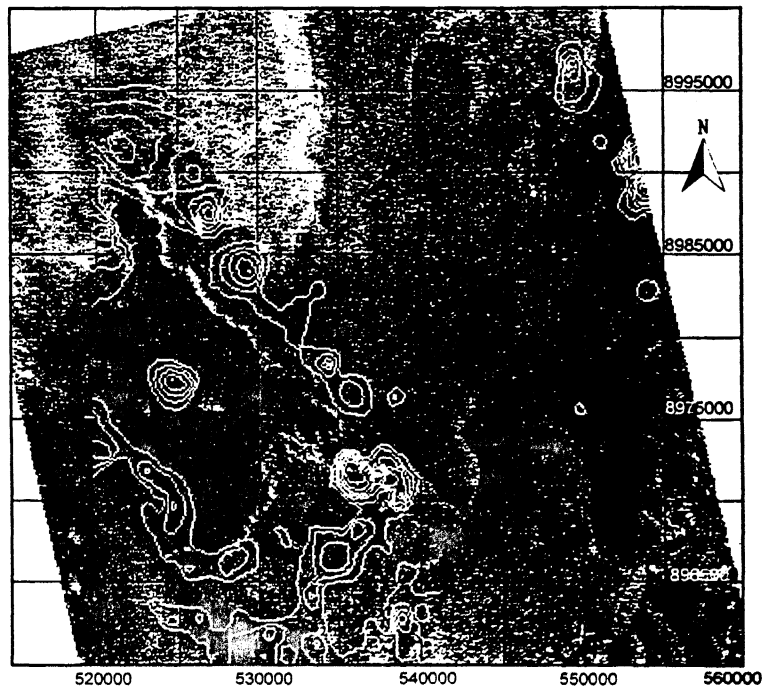


Figure 5. Radarsat image and anomalous areas of hydrocarbon microseepage.