Radiometric Survey of the Rancheria Sub-Basin-Colombia

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Abstract

The radiometric anomalies found in surface may be indirect indicators of hydrocarbon deposits subsurface, given by the vertical migration of hydrocarbons, water or other gases, which generate anomalies of different elements such as uranium-238, thorium-232 and potassium-40. According that, in the Rancheria sub-basin in Colombia were carried on 300 measurements of uranium-238, thorium-232 and potassium-40 in an area of 120 km2, approximately.

The radiometric survey was carried out with gamma ray spectrometer GR-135, where concentrations were determined in parts per million (ppm) of uranium-238 and thorium-232; while for potassium-40 units are in percentage. To compare the maps of each radioelement, the measured data were statistically standardized; these maps show negative radiometric anomalies that show a positive halo. These abnormalities can be associated with deposits of hydrocarbons. Also, there are positive anomalies, which can be correlated to the presence of hydrocarbons in depth. The study area comprise sedimentary and volcano-sedimentary sequences: characterized by Cretaceous clastic, carbonates sequences and Quaternary alluvial sediments. For the mapping radiometric anomalies, the data had been normalized, and they are not influenced by the lithology.

Introduction

In the deposits of hydrocarbons, the gases are released vertically by different mechanisms of transport to the surface, forming geochemical anomalies, which could be used to help infer where reservoirs in depth are. The studies of radioelements anomalies such as uranium-238, thorium-232 and potassium-40, are applied to explore oil and gas, relying on the presence of anomaly concentrations of these radioelements, generated in the soil by microseepage from the ground to the surface (Schumacher, 2000; Shuyun *et al.*, 2007).

Several studies in oil fields (Erickson *et al.*,1954; Fleischer & Turner, 1984; Mazadiego, 1994; Zhongjun *et al.*, 1995; Larriestra *et al.*, 2010), Show that the petroleum, natural gas, asphalt, shales of gas and oil rocks contain carbon dioxide (CO_2), hydrogen sulfide (H_2S), radioactive materials mainly uranium, radio, and other metals such as arsenic, cobalt, copper, chromium, manganese, molybdenum, nickel, lead, vanadium and zinc, which are sourced from the source rock or reservoir rock. For this reason the anomalies in surface has been used for the exploration of hydrocarbons.

According some authors (Saunders *et al.*, 1999; Schumacher, 2000; Etiope & Martinelli, 2002; Schumacher *et al.*, 2003), suggest that the radiometric anomalies in surface associated with the presence of hydrocarbons in depth they are given by: the light hydrocarbons, that by oil microseep migrated from the reservoir to the surface by bacterial action creates carbon dioxide and hydrogen sulfide, all of these conditions can alter the properties of the sediments, producing radiometric modifications.

Gases such as methane and carbon dioxide are called gas carriers, which help to transport radioelements toward the surface, generating radiometric anomalies in the ground.

The microorganisms produce chemically reducing environments, which over time can result in high concentrations of uranium.

Metals such as uranium associated with the source rocks or reservoir rocks of oil and gas, by differences in pressure and temperature are transported to the surface, deposited in reducing areas, where the Radium-226 (item from the chain of radioactive decay of uranium-238) is mobile and can be transported to the surface, deposited in areas oxidants, generating radiometric anomalies near the surface.

The migration of the hydrocarbon by oil microseep from the reservoir, are reducing areas where they are deposited the elements such as uranium, sulphides and oxides of iron, the hydrocarbon continues its migration toward the surface and finds an oxidizing zone, where they are precipitated carbonates, radio, calcium and magnesium forming calcite or calcite cement on the ground.

The authors Yuchun & Qing, 1995; Sikka & Shives, 2002; Li & Lin, 2010; Khattak *et al.*, 2011; Borchaninov, 2013 y Olson, 2015 Suggest that the radiometric values low, are produced on the fields of hydrocarbons and higher values radioactive anomalies are found at the edges of these deposits. This type of anomaly corresponds to anticlinal structures, forming on the surface anomaly in the form of halo.

The distribution and the vertical migration of radioactive elements contained in the oil, gas and water are the main causes of the formation of the radiometric anomaly in surface, finding high values in the center and low values on the edges of the reservoir. These anomalies are associated to structural traps.

Method

In the surface of the Rancheria sub-basin were taken 300 measurements, separated 300 m. The measurement collected comprise uranium-238, thorium-232 and potassium-40. The measurements were made with the gamma ray spectrometer GR-135, which made it possible to measure and analyze the emissions of gamma rays and the nucleoids to be subsequently mapped (ArcGis), using the statistical method of interpolation kriging, which expressed a percentage of average standard error of less than 1%, in the different maps.

The data were processed and standardized in order to make maps to identify areas with negative and positive radiometric anomalies.

Examples

The stratigraphy is described by diferente outcrop in South-west direction. To the north the Jurassic volcano-sedimentary rocks La Quinta Formation in discordant contact with sedimentary rocks of the Cretaceous (Cogollo Group, La luna and Molinos Fomations) to the Quaternary; La luna and Molino formations and Cogollo Group had been classified as source rocks of hydrocarbons, and reservoir rocks too, in accordance with geochemical studies, stratigraphic, seismic and well-logs (Cáceres *et al.*, 1980; García *et al.*, 2007; García *et al.*, 2009; Mesa & Rengifo, 2011). The radiometric data do not show trends with regard to the geology of the area.

The maps from the radiometric measurements on the ground carried out in the hydrocarbon Rancheria Sub-basin shows negative and positive anomalies. Towards the North in the central part (Figure 1 and 2) appear negative anomalies with high concentrations. This could be an indicator of the presence of hydrocarbons in depth. Similarly, in the northeastern part of the area, there is a positive anomaly of uranium and thorium and is negative with regard to potassium (Figure 3), could also be an indicator of hydrocarbons in the ground.

Results

According with the figures 1, 2 and 3, it is possible to show some radiometric anomalies. In the Figure 4, Green enclosed in circles represent some negative anomalies, while red color enclosed in circles exhibits the positive anomalies, that could be related to the presence of hydrocarbons in depth. The geology of the area does not show trends with regard to the anomalies found, for this reason, was discarded the influence of the concentrations of the radioelements measured with the lithology and structural geology of the area.

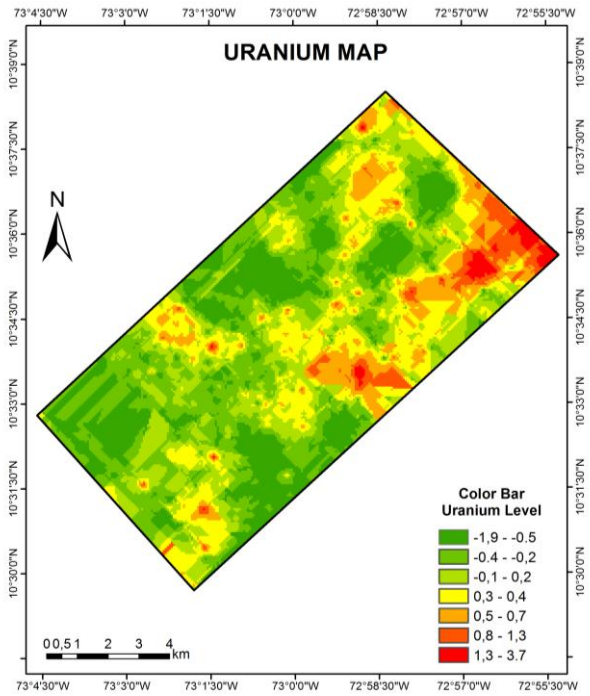

***Figura 1**. Anomalies of uranium, where it shows the negative anomaly to the center that increases towards the outside.*

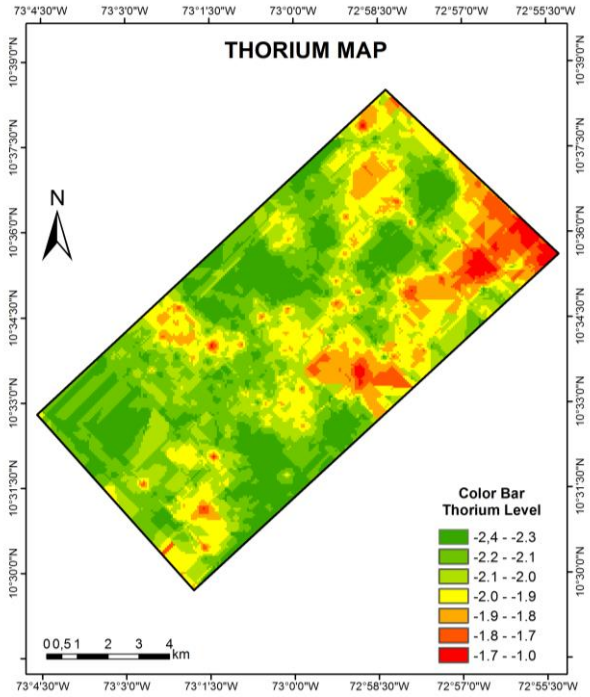

***Figura 2**. Anomalies of thorium, where it shows the same tendency of uranium.*

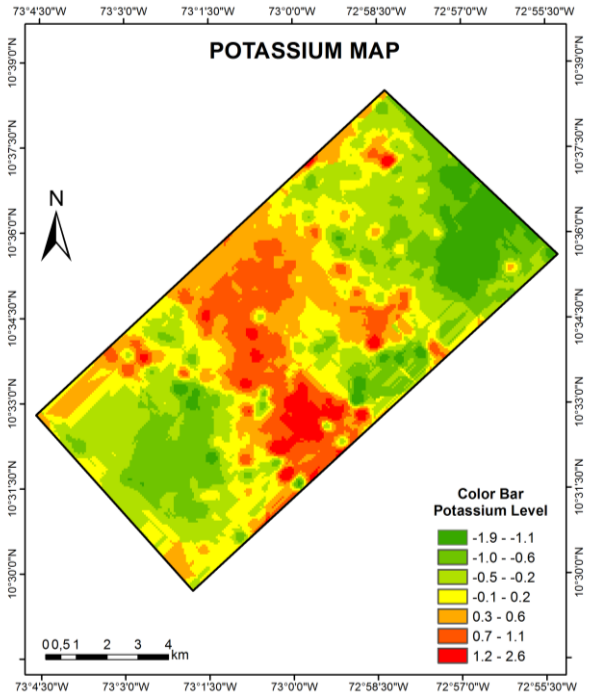

***Figura 3**. Radiometic anomalies of potassium-40*

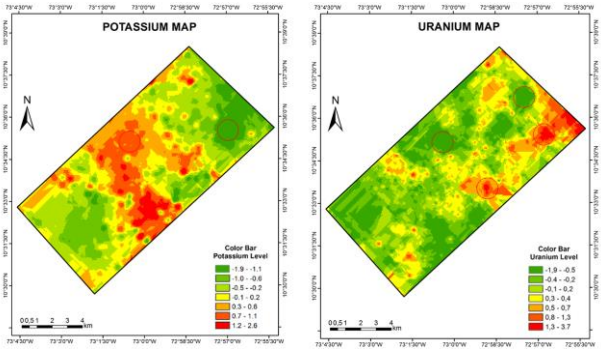

***Figura 4**. Positive and negative anomalies (red circle) that may be related to presence of hydrocarbon in depth.*

Conclusions

By comparing the maps with the radiometric data standardized, the trends of the concentrations of uranium and thorium are similar.

The maps show different positive and negative radiometric anomalies, which may be associated with hydrocarbon deposits in depth. In some sectors have low values of uranium and thorium and higher values of potassium, in other places the uranium and thorium values are higher with low potassium, this can be given by the different types of traps of hydrocarbon in the ground.

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