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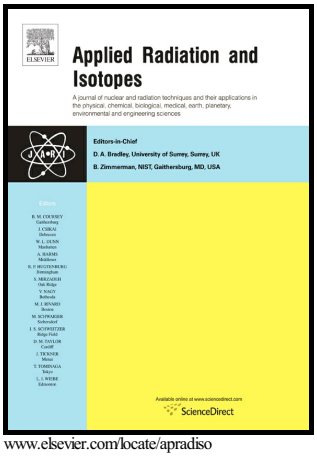

www.elsevier.com/locate/apradiso

PII: S0969-8043(18)30341-5
DOI: https://doi.org/10.1016/j.apradiso.2018.07.023
Reference: ARI8428

To appear in: *Applied Radiation and Isotopes*

Received date: 10 April 2018
Revised date: 29 May 2018
Accepted date: 18 July 2018

Cite this article as: Sonia Salazar, Luis Castillo, Luis Montes and Fabián Martínez, Utilizing the Radiometric and Seismic Methods for Hydrocarbons Prospecting in the Rancheria Sub-Basin in Colombia, *Applied Radiation and Isotopes,* https://doi.org/10.1016/j.apradiso.2018.07.023

Utilizing the Radiometric and Seismic Methods for Hydrocarbons Prospecting in the Rancheria Sub-Basin in Colombia

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Resumen

An onshore radiometric survey sampled in situ the isotopes U^{238}, Th^{232}, K^{40}, and Rn^{222} to build maps of normalized values for each element containing negative and positive radiometric anomalies, which could associate with hydrocarbon deposits in the subsoil. The vertical migration of hydrocarbon, water or other gases would have generated the different isotope anomalies. In four 2D seismic sections of the study area, three on dip direction and another in strike direction, we interpreted unconformities, flooding surface, and maximum flooding surfaces, as well as Cretaceous tops. In structural contour maps made from aforementioned seismic sections, we observe structural highs and structures such as truncations of strata. These structures in-depth coincide with uranium, thorium, potassium and radon anomalies seen on the surface. This oil and gas exploration approach that integrates radiometric and emanometric integrated with seismic prospecting can help to reduce the risk in hydrocarbons projects (however, radiometric anomalies are not uniquely associated with hydrocarbons). This work shows a correlation between radiometric (uranium, thorium, and potassium) and emanometric (radon) data in the surface with structures in the subsurface suck like truncation, that could present hydrocarbon, however, on this sub-basin, there has not been found commercial hydrocarbon.

Keywords: uranium, radon, radiometric, seismic, hydrocarbon exploration, Rancheria Su-Basin, Colombia.

Introduction

Chemical elements generated in the subsuface, migrate by different mechanisms of transport through towards the surface like micro-fractures and microseep (Mazadiego, 1994, Schumacher, 2000, Shuyun *et al*., 2007). Similarly, gases vertically released in hydrocarbon deposits reach the surface, forming geochemical anomalies used to infer hydrocarbon reservoirs (Tedesco, 1995; Schumacher, 2000). Therefore, analysis of radioactive element anomalies focuses on high concentrations of U^{238}, Th^{232}, K^{40}, and Rn^{222}, sampled in the surface. On the other hand, studies in hydrocarbon fields (Erickson *et al*.,1954; Laubenbakh & Skosyreva, 1958; Long, 1975; Fleischer & Turner, 1984; Zhongjun *et al*., 1995; Yanaki *et al*., 1999; Mavrichev & Molodtsov, 2000; Gallagher, 2010; Larriestra *et al*., 2010; Palacios *et al*., 2013; Nigm *et al*., 2018), showed that oil, natural gas, asphalt, gas shales and oil rocks contain carbon dioxide, hydrogen sulfide, radioactive materials mainly uranium, radium, and other metals such as arsenic, cobalt, copper, chromium, manganese, molybdenum, nickel, lead, vanadium and zinc, together with gases such as helium and radon, which come from reservoir or the source rock. Some studies (Saunders *et al*., 1999; Schumacher, 2000; Etiope & Martinelli, 2002; Schumacher *et al*., 2003, Schumacher, 2010) suggest that surface radiometric anomalies would associate with hydrocarbon deposits in depth. The light hydrocarbons migrate from the reservoir to the surface through micro-fractures whereas the bacterial action creates carbon dioxide and hydrogen sulfide. The carrier gases methane and carbon dioxide can transport radioelements to the surface, generating radiometric anomalies there. Radioactive elements, such as uranium, are associated with gas-oil reservoir and source rocks.

By pressure and temperature differences, these elements are transported upwards and trapped in reducing zones, where Ra^{226} is mobile. From there, Ra^{226} migrates to the surface and deposited in oxidizing zones, generating radiometric anomalies such as radon anomalies near the surface. Uranium, sulfides, and iron-oxides deposit in areas of reduction formed during the migration of hydrocarbons. The hydrocarbon continues migrating to an oxidizing zone in the surface, where carbonates and radium precipitate while calcium and magnesium form calcite or calcite cement. Some researchers (Yuchun & Qing, 1995; Sikka & Shives, 2002; Li & Lin, 2010; Khattak *et al*., 2011; Borchaninov, 2013; Olson, 2015; and Nigm *et al*., 2018). Some authors (Yuchun & Qing, 1995; Sikka & Shives, 2002; Saunders 2002; Nigm *et al*., 2017; El-Khadragy *et al*., 2018), among many others have observed (or documented) that radiometric “lows” are commonly associated with hydrocarbon accumulations., has stated that Th-normalized K concentrations shown relatively consistent low values over hidrocarbons accumulations, whereas Th-normalized U concentrations may show either low or high values. On the other hand, the edges of these deposits produce high quantities of radioactive anomalies. This type of abnormality corresponds to anticline structures, forming a superficial distribution in the form of a halo. The distribution and vertical migration of radioactive elements contained in oil, gas, and water in the subsoil cause anomalies on the surface. The high values of uranium, thorium, potassium, and radon are in the center and low measurements in the edges of the reservoir. These anomalies relate with fault.

Data and study area location

The study area is at the Northeast of Colombia, in the state of La Guajira, between the towns of Villanueva and Urumita. It covers an approximate area of 120 Km^2 within the Rancheria sub-basin (Fig. 1) and comprises 300 stations of surface