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USE OF 226RA AND 228RA RADIOMETRY IN THE INVESTIGATION OF NORM FORMATION PROCESSES IN SHALE GAS

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INTRODUCTION

The exploration of shale gas and shale oil requires use of the technique of fracking (hydraulic fracturing), that is, injection of high pressure fluid with water, sand and chemicals, to release hydrocarbons from the geological formations. Shale is a sedimentary rock, that usually exhibits quite fine particle sizes, low permeability, and plenty of organic matter [1], besides low concentrations (on a mass basis) of natural radioactive isotopes. Fracking can mobilize naturally occurring radioactive materials - NORM – that are present in the rocks. As a result, radium salts will form incrustations on the inside walls of production wells and surface equipment [2]. The radium isotopes - 226Ra and 228Ra species - may be considered the pivotal NORM's in fracking effluents, considering their leverage role among long- and short-lived radionuclides in the 238U and 232Th decay series. Fig. 1 presents examples of pathways traversed by NORM's during oil and gas exploration and production.

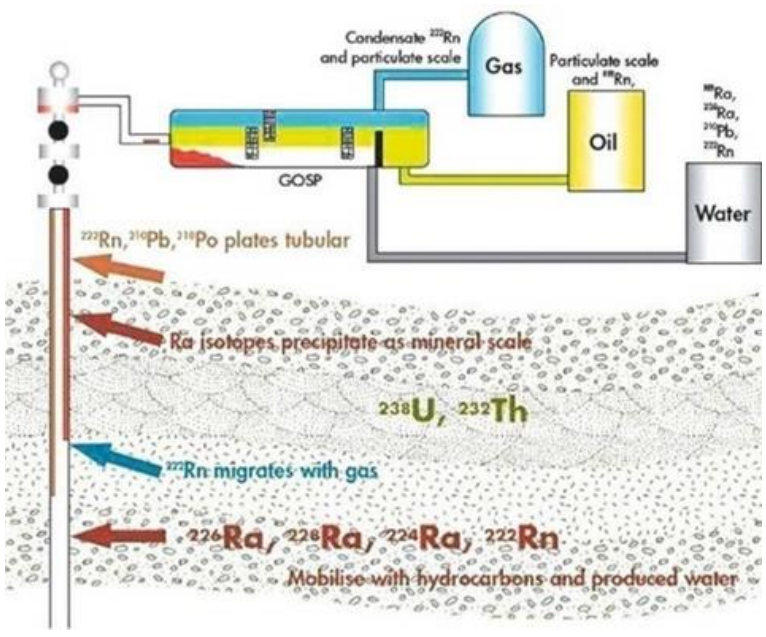
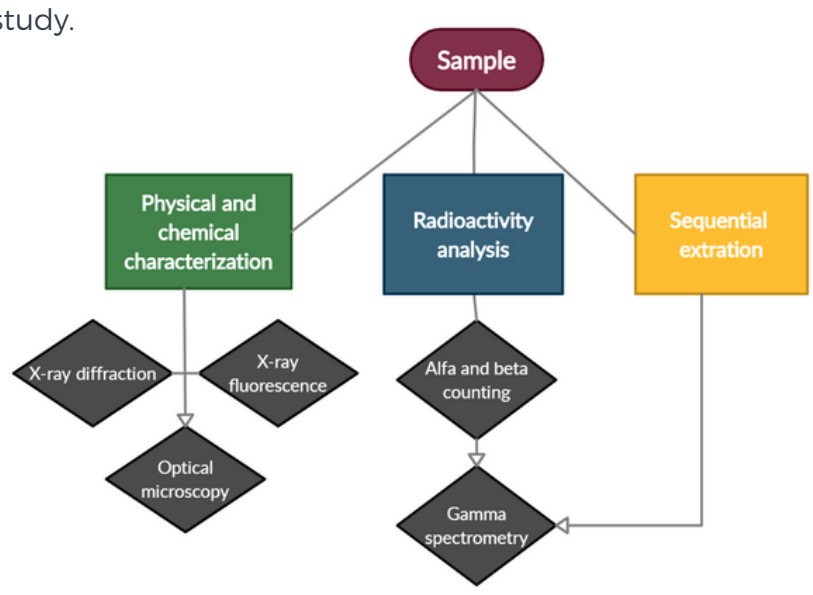


Fig.1: *Most common NORM sources and transport pathways in oil and gas exploration [3]*

The present work aims to develop a methodology to investigate the processes of NORM evolution in shale gas exploration by means of 226Ra and 228Ra radiometry. The study area is the São Francisco Geological Basin. Deep investigations (down to 2,000 m) identified intervals containing dark organic-rich (3.5% total organic carbon) and radioactive shale layers. These shale layers are the gas source rocks of interest in this research.

METHODOLOGY

The flowchart 1 displays the methodology developed during the study.



Flowchart.1: *Methodology developed*

Geological profiles of four wells were also analyzed from the São Francisco Geological Basin available at the National Agency of Petroleum, Natural Gas and Biofuels – ANP.

In these profiles the presence of shale layers, as well as their gamma spectra, resistivity spectra, density/porosity, and geologic formations were studied.

RESULTS

Due to the pandemic COVID-19, the process for requesting rock samples from ANP has been delayed. However a sample from the Recôncavo Basin has been made available which permitted the development of an appropriate methodology for shale inspection and its application in the requested samples. The x-ray diffraction analysis identified the minerals Muscovite, quartz, albita, calcite, and anquerite. The X-ray fluorescence is complementary, defined and quantified the oxides, for example SiO_2 (59.2%), and Al_2O_3 (17%). Fig. 2 identifies one mineral in optical microscopy.

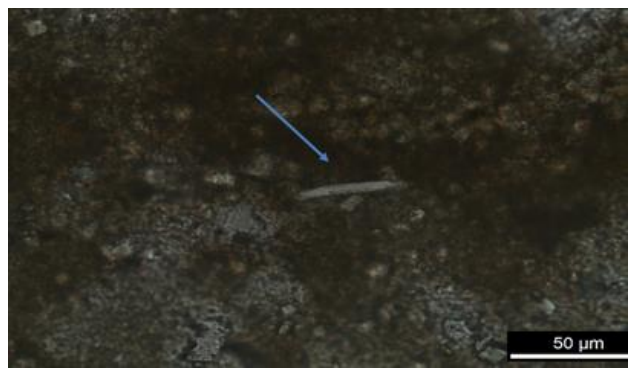


Fig.2: *Optical microscopy of the surface shale showing a mica.*

The results of the alfa beta counting were quite low; alfa = 0.21 ± 0.09 Bq/g and beta = 1.00 ± 0.09 Bq/g. This measurement is a screening test for sample radioactivity; in case the results are higher than thresholds defined by public authorities, the sample should be submitted to specific radionuclide analyzes. After this analysis, the sample was measured by gamma spectrometry and the following specific activities is show in the Table 1.

Table 1: Results of the gamma spectrometry

Sample	Ra-226 (Bq/g)	MDL (Bq/g)	Ra-228 (Bq/g)	MDL (Bq/g)
Solid	0.015 ± 0.002	0.005	0.045 ± 0.005	0,02
Liquid	ND	0.0004	ND	0.001

MDL: Maximum Detected Limit; ND: Not Detected

CONCLUSION

The proposed methodology for the characterization of shale has partially proved satisfactory. However, complementary analyses and sequential extraction test have to be performed to characterize appropriate shale samples and potential risks of shale borne NORM, and the accession to the samples already required to ANP will be of major importance to conclude the project. The results of this research may contribute to the management of NORM in wastes from the shale gas industry in Brazil, and thus assist in preventing environmental contamination.

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CDTN Centro de Desenvolvimento da Tecnologia Nuclear
anp Agência Nacional do Petróleo, Gás Natural e Biocombustíveis
Rede Gasbrás Seção Minas Gerais
Finep Inovação e Pesquisa Empresa Pública do MCTI