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ABSTRACT

The solid state nuclear track detector technique was developed to be used in radon detection, by alpha particles tracks, and has been applied in uranium prospecting on the ground.

The sensitive films to alpha particles used were the cellulose nitrate films LR 115 and CA 8015. Several simulation experiments and field measurements were carried out to verify the possibilities of the method.

Maps of some anomalies in Caetité City (Bahia, Brazil) were made with the densities of tracks obtained. The results were compared with scintillation counter measurements.

DETECÇÃO DE RADÔNIO EM SOLOS POR MEIO DA TÉCNICA DE DETECTORES DE TRAÇOS NUCLEARES DE ESTADO SÓLIDO

RESUMO

Neste trabalho desenvolveu-se a técnica de utilização de detectores de traços para a detecção de radonio por meio do registro dos traços de partículas alfa, e efetuou-se sua aplicação na prospecção de urânio em solos.

Foram utilizados os filmes de nitrato de celulose, sensíveis às partículas alfa, LR 115 e CA 8015. Experiências de simulação em laboratório e medidas de campo foram efetuadas para verificar as possibilidadess do método.

Com as densidades de traços obtidas na região de Caetité (Bahia, Brasil) foram feitos mapas. Os resultados foram comparados com as medidas feitas utilizando um cintilador.

1. INTRODUCTION

Radon is an inert gas element of atomic number 86. There are three Radon isotopes: ^{222}Rn (usually named as radon), ^{220}Rn (called thoron) and ^{219}Rn (called actinon.) ^{222}Rn is a member of the decay serie of ^{238}U, ^{220}Rn comes from ^{232}Th and ^{219}Rn from ^{235}U. These isotopes are the only gaseous elements of the chains. Radon isotopes are alpha emitters (^{222}Rn with a half-life of 3,82 days and alpha energy of 5.49 Mev, ^{220}Rn with $T_{½}$ = 51.5 sec and alpha energy of 6.28 Mev and ^{219}Rn with $T_{½}$ = 3.92 sec and alpha energy of 6.82 Mev). The detection of these alpha particles provides a sensitive way of detecting radon.

Radon monitoring is of importance in connection with three main applications:

1. uranium/thorium prospecting[3]
2. radon dosimetry in uranium mines[1]
3. earthquake prediction[4].

In this work the Solid State Nuclear Track Detectors Technique was developed to be used in radon detection by alpha particles tracks and it was applied to uranium prospection from the top soil.

2. EXPERIMENTAL METHOD

2.1. Solid State Nuclear Track Detectors

Ionizing particles deposit energy along their path when they travel through matter. In some insulating materials called solid state track detectors this energy loss creates a submicroscopic cylinder of damaged molecules, the so called latent track. This latent track is not visible under optical microscope examination. However, if the detector material is placed in a convenient chemical reagent the volume around the track will be etched out preferencially so that the track of the nuclear particle becomes visible under optical microscope.

All of these materials are mostly insensitive to light, X and gama rays and electrons[2].

2.2. Radon Detection

Radon isotopes are being constantly produced and released in soils, water and the atmosphere[3,1], by two processes: diffusion and/or transportation[7].

The possibility of using radon (^{222}Rn) as an uranium prospecting tool was first suggested nearly 50 years ago[5] but it has only been during the last 10 years that solid state nuclear track detectors have been used for this purpose.

The alpha particle released due to the decay of thoron (^{220}Rn) will also penetrate the film detector. Thoron has a very short half life as compared to that of ^{222}Rn. Therefore, as it decays away very fast, thoron can be expected only in the very vicinity of thorium bearing minerals. In this case it is not possible to discriminate alpha tracks from ^{222}Rn against those from ^{220}Rn. Thorium minerals located at more than 30 to 40 cm from the place of detection are not likely to have any appreciable influence on track counts. The Radon-219 contribution may be disregarded because it has a short half-life and the percentage of U-235 is much less than U-238.

The basic principle of the method is quite simple. A number of closed tubes (inverted) are placed in holes (60 cm deep) in the ground and then covered. In each tube there is a piece of alpha plastic film with dimensions (1.5 x 1.5) cm^2, gummed in the middle and upper part of this tube. Then radon starts accumulating into the tube and decays away by emitting alpha particles that are recorded. The tube is left in place for several weeks. The alpha track densities on the film will be proportional to the amount of accumulated gas.

After the exposition time the pieces of film are removed and submitted to chemical etching. The films are read to determine the number of alpha tracks recorded.

For the detection of alpha particles the Kodak-Pathé cellulose nitrate films CA 8015 and LR 115 type 2 were used. The films were etched in a 10% NaOH solution at a temperature of 60.0 ± 0.5°C for 120 minutes with constant stirring. After chemical etching the films are rinsed in running cold water, for 30 minutes and dried. The number of tracks was determined by counting them with the aid of a Reichert screen microscope at a 140 X magnification[6].

3. RESULTS

3.1. Detector Features

Several pieces of film LR 115 and CA 8015, after being exposed to Rn and daughters radiation, were etched under the above conditions for a variable length of time.

The results (LR 115) are plotted in Figure 1 with the corresponding values for background on the films, and shows a linear increase between detection efficiency and etching time, probably due to greater number of latent tracks produced by alpha particles of greater energy (deeper tracks). After 180 min. of etching time, the films were degraded. The background tracks shows a exponential increasing after 130 min. of etching time.

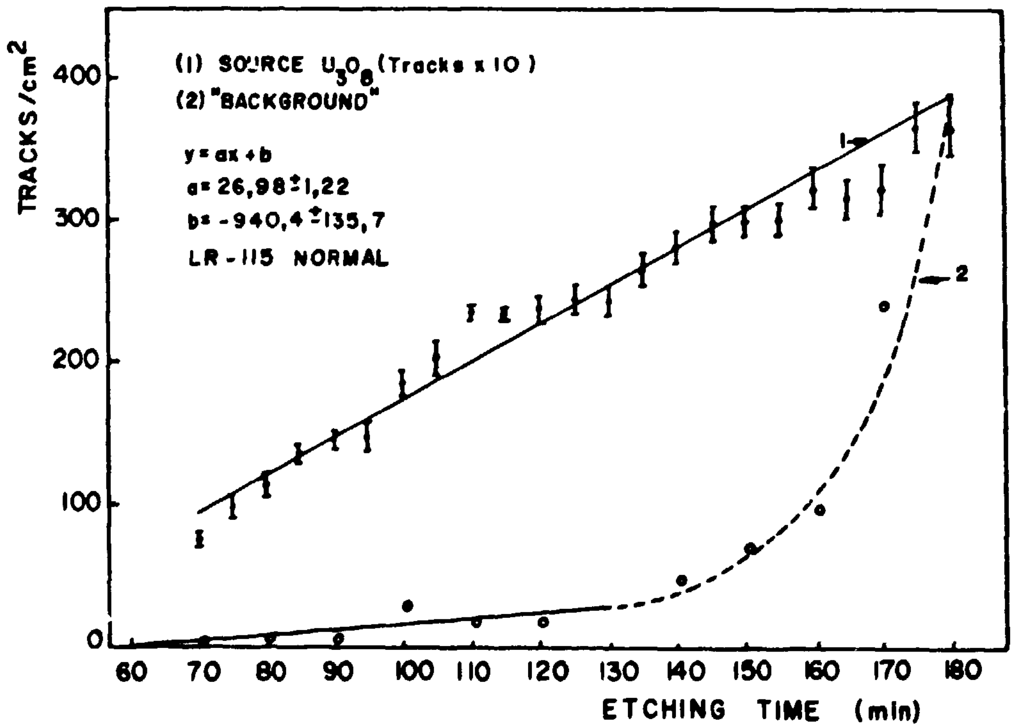

Figure 1 — Track density as a function of etching time. Curve 1 — Curve obtained using a source of U_3O_8. Curve 2 — It was plotted with background track density. The errors bars are statistical only.

We chose 120 min. as a convenient etching time due to the rising .ue of the background and track dimensions after etching, when seen under microscope[6]. The CA 8015 has a similar performance but is more efficient because it is thicker and it has a larger intrinsic background than the LR 115 film. Both films can bear densities up 400.000 tracks/cm^2[6] then we can use them in field measurements. The LR 115 is easier to scan in optical microscope due the fact that tracks appear as bright spots against a deep red background.

A series of experiments were carried out to observe the variation in track density with the size of the tube containing the detector and with the detector in the tube as well. (Figure 2).

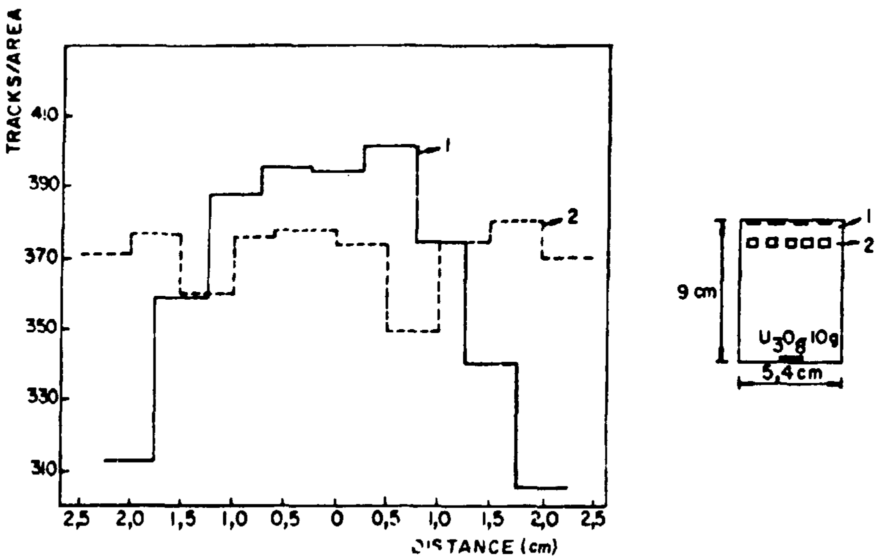

Figure 2 — Efficiency of detection as a function of the film position in the detectors. The best position was found in the middle and in the upper part of the detector.

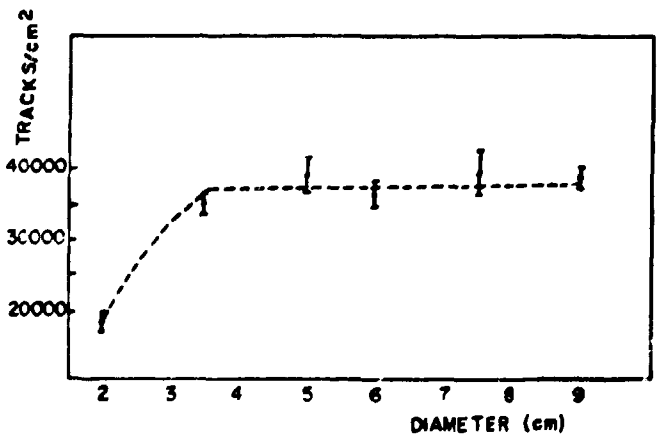

Figure 2a — Efficiency of detection as a function of detectors diameter. The errors bars are statistical only.

The tubes used this work were 5.4 cm in diameter (convenient efficiency) and 9 cm long (permitting that only alpha particles from radon and daughters reach the films) and the films were placed as shown in Figure 3.

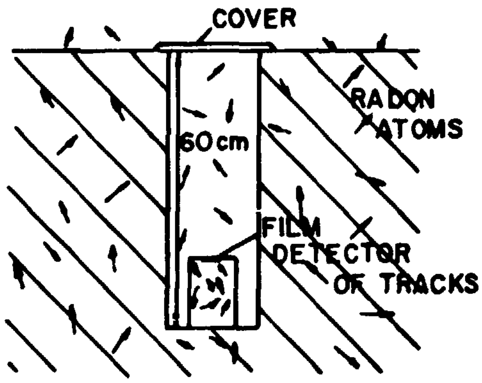

Figure 3 – Position of the detector in the field measurements.

3.2. Laboratory Simulation Experiments

We carried out simulation experiments in laboratory. Uranium samples (U_3O_8) of different activities were buried in sand and detectors were placed as shown in Figure 4. The results (Figure 5) prove that the location and identification of ore bodies, with the help of alpha sensitive plastic films, is feasible.

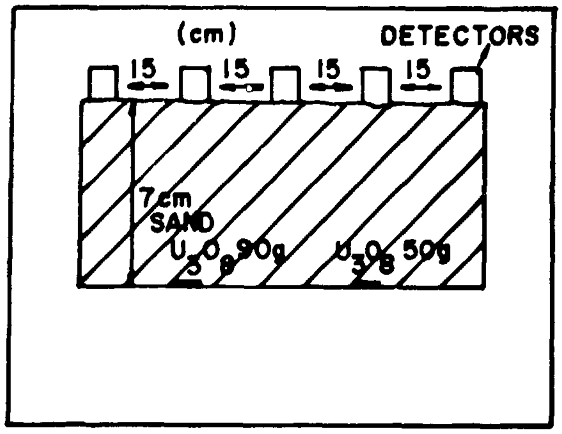

Figure 4 – Simulation experiments carried ou in laboratory with uranium samples buried in sand.

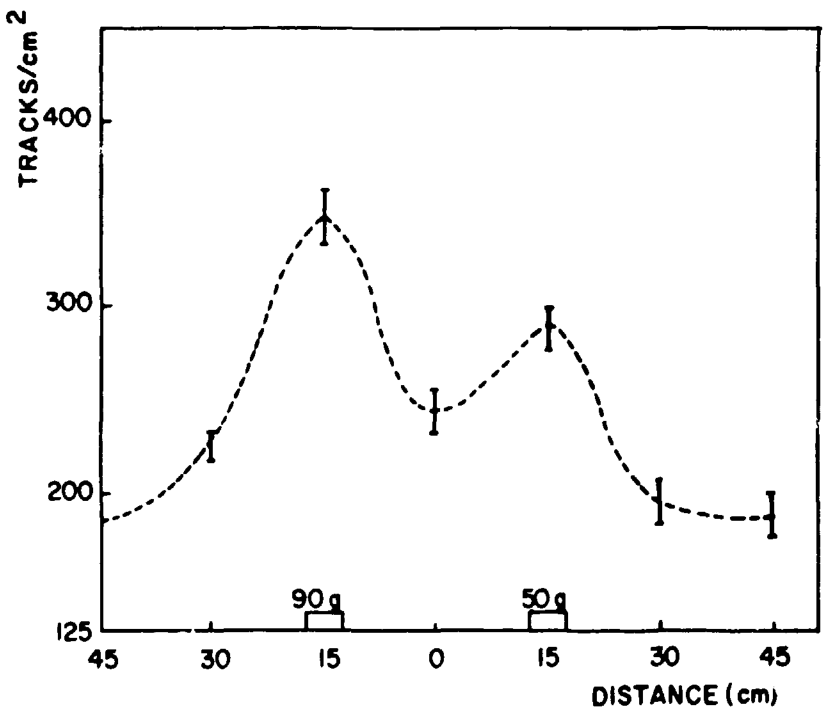

Figure 5 – The results show the location and identification of ore bodies.

3.3. Field Measurements

Maps of three anomalies in Caetité City region (Bahia, Brazil) were made with the track density results obtained with detectors placed in a grid pattern form. In this region there is a mineralization of uraninite in albite.

Anomaly 7 – 80 detectors were placed at knots of a grid 50 x 50 meters.

Anomaly 8 – 98 detectors were distributed in an area of 40 x 50 meters.

Anomaly 9 – 50 detectors in 80 x 100 meters.

In each point of the grid, after digging the holes, radiometric measurements with scintillometer within each hole were carried out.

The track densities obtained were used as input data to a computer which gives the results as a Contour map showing the most promising places for ore localization. The results were compared with scintillation counter measurements performed in the same area[6].

The results of Anomaly 7 are showed in Figure 6. The films were left in place for 15 days. The results obtained with the two methods, scintillation counting and track detectors measurements were similares, and it happened in the other two anomalies too.

Anomaly 07

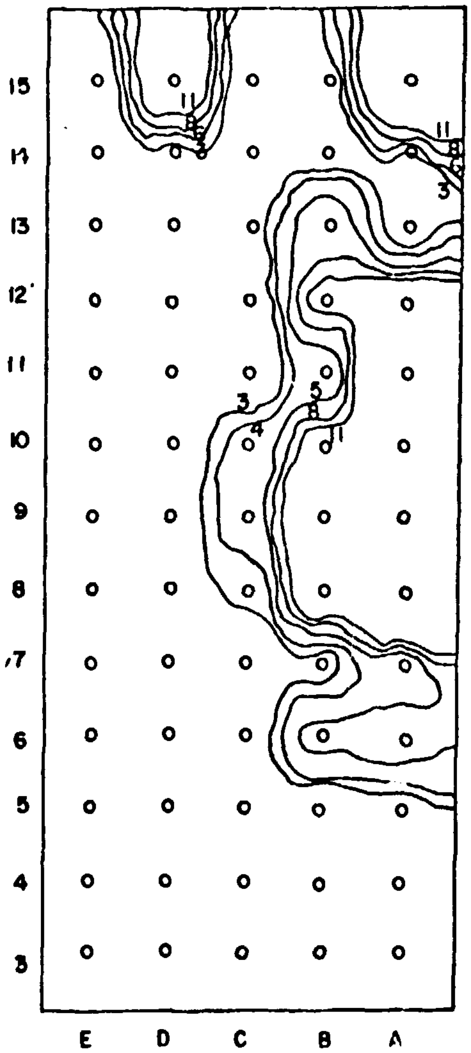

Figure 6a – Contour Map obtained with track detector measurements in anomaly 07

Line	Values (background = 1)
3	7 – 9
4	10 – 11
5	11 – 13
6	13 – 15
8	17 – 19
11	23

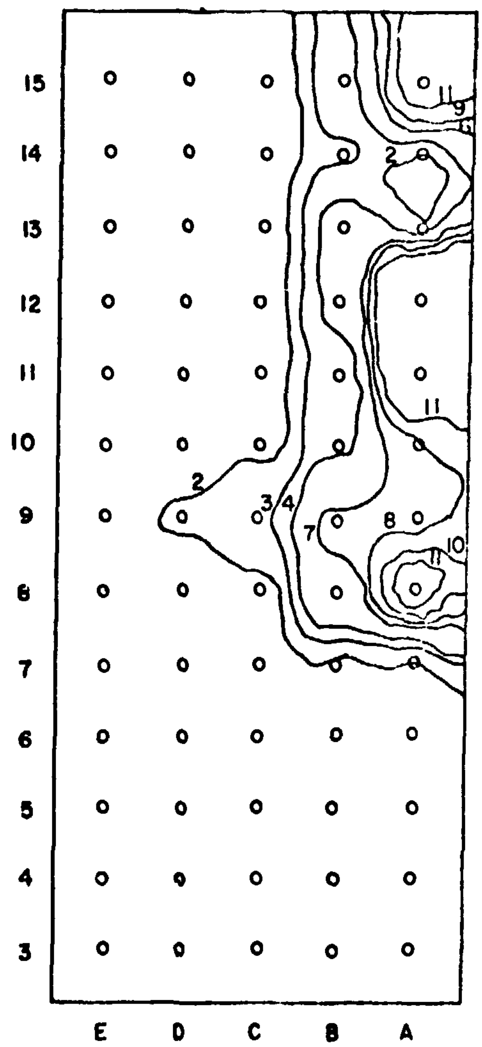

Figure 6b – Contour Map obtained with scintillation counter measurements in anomaly 07

Line	Values (background = 1)
2	2 – 3
4	4 – 5
6	6 – 7
8	8 – 9
10	10 – 11
11	11

4. CONCLUSIONS

The method is simple and an effective auxiliary technique for the prospection of buried uranium ore bodies., The radon contour maps can guide the initial drilling phase so that the exploration costs can be reduced drastically.

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