

A RADIOACTIVITY GIS MANAGEMENT OF PEGMATITE ROCKS IN THE SERIDÓ REGION

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INTRODUCTION

This paper presents the preliminary evaluations of a study accomplished on the radioactive minerals and secondary minerals of uranium that occur in pegmatites of the Seridó Region (State of Rio Grande do Norte, Brazil) and their relationships with the several sources of water provisioning and population nuclei of the area of the municipal district of Parelhas and Equador (RN). In general, the pegmatites of this area have radioactive indexes associated to dispersed uranium in the crystalline lattices of different minerals (albite, microcline, tourmaline, lepidolite, quartz, apatite, and other phosphate minerals), and also for the presence of primary and secondary minerals of uranium (pitchblende, gumite, autunite, meta-autunite, torbernite, meta-torbernite, uranophany, beta-uranophany, phosphuranilite, cleveite, sabugalite, uranomicrocline, uraninite and opal uraniferous). These minerals of uranium appear associated to the rifts and cavities in the pegmatite rocks and in the tourmaliniferous granites, and they were identified by petrographic studies, X-ray diffraction, chemical analysis (ICP-MS and OES) and electron microprobe, as well

as by analysis of ultraviolet fluorescence, infrared spectroscopy, radioactivity counting and thermal behavior.

In the measurements carried out in this area, the regional radioactive background in the granitic areas varies from 250 to 350 counts/second, while in the pegmatite areas the variation is much larger (500 to 1000 cps). Geochemical studies and preliminary environmental hydrochemical analyses suggest that the acid underground waters and oxidizers attack and dissolve the radioactive minerals in the pegmatite, generating solutions rich in salts of uranium [UO_2CO_3 and $\text{UO}_2(\text{CO}_3)_2^{2-}$]. These solutions remaining acid, will contaminate the aquifers, unless they find a geochemical barrier (alkaline and reductant) that will force the precipitation of autunite and other secondary mineral of uranium, as it happens in some pegmatite occurrence in the area of Parelhas.

The initial part of this study evaluates the distribution of the pegmatites of larger concentration of radioactive minerals and make a spatial analyses. A Geographic Information System (GIS) was elaborated focusing the space analysis of these occurrences, and seeking the storage of these data and its easy manipulation, aiming at the analyses of the relationships

of the occurrence of these radioactive minerals with their proximity to sources of water supply and habitation nuclei.

MATERIAL AND METHOD

The development of this project includes several stages that sequentially were developed over two years. Initially the traditional geological procedures, such as photo-interpretation, treatment of images of satellites focused on the identification of the pegmatite occurrences, mapping and interpretation of data, and selection of the objectives that deserved the detailed study were accomplished. In this phase the regional recognition of the distribution of the occurrences of pegmatites was sought, in peculiar with indications of radioactive minerals, definition of the type of work methodologies with these mines and the identification and choice of the occurrences that would be studied in full detail in the second stage.

Approximately 90 occurrences of pegmatite were visited and classified in the database. This database joins the geological and geotechnical details of the pegmatite occurrences and, at the same time, identify the proprietors, the exploration forms and the peculiarities of each body, aiming at a better knowledge of its space distribution in the area.

These objectives were chosen, taking into account the space distribution of the radioactive occurrences, seeking the best representation of its distribution in the area. In a subsequent stage, the main pegmatite occurrences (25 occurrences) bearing radioactive minerals, were investigated and mapped geologically in detail in the scale of 1:500, with topographical and geological evaluation and assessment of the amounts of radioactive minerals, their disintegration capacities, solubility and transport.

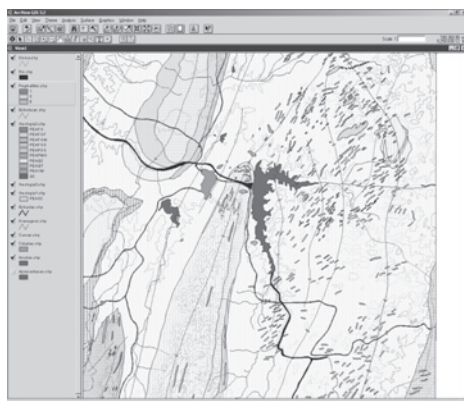


Figure 1 - Geological map of the Area and main pegmatite occurrences (prolonged polygonal forms).



Figure 2 - Satellite Image SPOT with treatment of emphasis of the pegmatite mines (Peg) in the form of outstanding white stains.

On the modality of a Geographic Information System (GIS), the possibility of segmentation was opted, in a way to propitiate his popularization through the net, without the need to transfer the whole database, and respective maps, being permitted like this only the transmission of the relative data to the interested mines chosen as target of analysis and peculiar of interest. The system joined in its database, the information collected by the project, such as: name of the occurrences, illustrative photos, geo-referenced procedures of the mines by UTM coordinates, references on the proprietor and of the land where it is located, access roads and their use conditions, physiographic aspects, with projection on the infrastructure conditions, situation and type of current exploitation, lithology and stratigraphy of each analyzed occurrence, geology, topography, description and the technical evaluation of each pegmatite body, main radioactive minerals and their concentrations, as well as the data regarding the regional hydrography, occurrences of water, drainage highways, population nuclei and affected urban areas, environment conditions, as well as an analysis of the companies already established in the studied area that sell these minerals.

This GIS besides giving support to the proposed objectives, still has as goal the future management of the results analyzed by this project, in a way to allow that any new project, or any new dataset such as new geochemistry analyses and technological evaluations of the radioactive minerals, and their relationships with present diseases in the population that will be generated (following phase of this project), could be enclosed to the database and make the maps updated automatically.

RESULTS AND CONSIDERATIONS

The studies identified numerous pegmatite occurrences with medium and high indexes of concentration of radioactive minerals (predominantly: Perus, Tancos and Tanquinho, Boqueirão de Parelhas, Gis and Alto do Gis, Santino e Alto do Santino, this two last where the variation of radioactive is much larger than 500 to 1000 cps) that were registered and georeferenced in the GIS. These pegmatite occurrences were, almost always, close to occurrences of water and population nuclei that use these sources of water for consumption.

The possible usage relationships and the direct impact of these radioactive mines on the water used by the population were modeled in GIS, seeking establish where the acid underground waters can oxidizers, attack and dissolve the radioactive pegmatite minerals, generating solutions rich in salts of uranium [UO_2CO_3 and $\text{UO}_2(\text{CO}_3)_2^{2-}$].

Uranium is a poisonous element, affecting mainly the kidney. The manipulation of its minerals (mineral extraction) and also their decomposition and transport using water with subsequent consumption for the population are one of the current public health problems in this area. The minerals of uranium, as well as those of thorium present three types of risks basically due to their radioactivity. These risks are the external irradiation, the internal irradiation after ingestion of uranium, and the contamination by inhalation of radon and its decay products.

In the case of this project, the risk of the external irradiation and its propagation in the area, in some cases doesn't seem to be excessively serious due to the absence of population concentrations close to the pegmatite occurrences with radioactivity. As the received radiation decreases with

the square of the distance, this type of contamination only happens when the prospectors open work front in these more polluted occurrences. Even so this effect is reduced partly because an important portion of the emission of the uranium and thorium is in form of alpha particles which has much reduced penetration power, being mostly retained by the air or by the own mineral layers that stop great part in its interior. The concern in this case happens when the prospectors, looking to extract other minerals and precious stones of these pegmatite rocks, execute procedures evidently imprudent, as work in galleries with little ventilation, what strongly increases the radon concentration in the air, as well as to concentrate and to store radioactive samples in places closed to courses of water, or even taking the samples home, what will convert it in a "radioactive anomaly."

In the area, the internal irradiation is one of the most predominating contaminations, due to the fact that prospectors do not have any deeper knowledge of the dangers and do not use protection equipments. It is common that they manipulate radioactive minerals and do not wash their hands before taking meals or additionally smoking. This behavior may result in accidents provoked by ingestion (already registered), that depend on the toxicity, solubility of the mineral and its division degree and may have quite aggressive effects.

In the mines that already developed work in sub-surface, the emanation of the gas radon (^{218}Rn , ^{219}Rn , ^{220}Rn and ^{222}Rn), product of the decay of radium derived from uranium and of thorium, and that is intimately associated to the granitic rocks and to the minerals of Uranium and Thorium can be the largest risk in a closed space and little ventilation, e.g. in the galleries where it can be concentrated.

On the other hand, the contamination of water by radon is controlled by the chemical concentration of the element radium (Ra) in the soils that cover these rocks through where the water percolate, and still for the emissivity of this radioactive gas in fractures that are underlying to ponds, dams and other sources of water. As the isotope ^{222}Rn possesses a time of half-life sufficiently brief (3,82 days), we can consider as an important radionuclide, relatively to the emanations of the soil and its dissolution in the waters. The goal of this final stage of the work was to define the factors that could control the distribution and the form of occurrences of the radioactive minerals in several occurrences of the studied pegmatites, to classify them in different types (homogeneous and heterogeneous), to frame them in the regional geological context, and to evaluate their potentiality in producing environmental contaminations.

CONCLUSION

Of the 25 occurrences selected as bearers of expressive concentrations of radioactive minerals, ten do not represent a direct danger for human health because they are abandoned already and the prospectors are careful, not exploring them because they know the level of danger. Other nine occurrences present risk to the human health as they are explored with the use of deep galleries that can concentrate the radon in their interior. The other six occurrences were classified as dangerous due to occurrences of minerals as uranomicrolite and uraninite in concentrations that can affect the prospectors and others that work there.

The application of the methodologies of GIS for the chosen theme met the initial expectations of the project. The experience was shown valid in first place

for the expressive fact of having allowed an evaluation of the potential of the occurrences with presence of radioactive minerals of this area and a classification in a setting of unified register database. Starting from this study we have an updated database that conserves the information on all of the aspects of the area that are necessary for an evaluation of the impacts of the exploration of the mines and the respective relationship with the public health problems.

The system was shown quite dynamic and simple, allowing a fast search at the same time by the people that don't possess larger experiences in GIS, but also allowing the elaboration of consultations more deepened and the generation of other thematic maps for professionals of the area. The implementation of a GIS that could agglutinate all of the information obtained in an unique system and simple overcoat, with the perfect interaction of the several components geological, physical, chemical and geographical of the project made available a quite useful tool for the entities interested in the analyzes of the problem of the radioactivity. This serves as base for the stages that will be proceeded,

of analyses of the implications of these pegmatites with radioactivity presence in the health of the populations of the area. It is mainly for the fact of the whole project be geo-referenced that the system makes possible the integration with other projects that are, or that will come to be executed in this area, showing vast future applications.

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