



Radiogenic Heat Production in Some Sites of Irecê Sedimentary Basin, Bahia, Brazil

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ABSTRACT: This article is a research product engendered in the north central portion of the State of Bahia, Brazil, in the sedimentary basin areas of Irecê. These sites were collected 40 fresh samples of limestone and calculated its density, degree of porosity and taken the contents U, Th and K by the method of gamma spectrometry. With the numerical values of the variables mentioned above, it calculated the dissipated heat flow using an empirical formula. It was found that the higher density samples showed the most energy dissipation and the reverse for the lower density samples. These findings are directly related to mineralogy present in the samples, the rock types occur where mineral Pb, Zn and Ba contain higher levels of radioactive elements (U, Th and K). The results possibly serve as a reference for modeling hydrogeochemical, they express the energy required for the initiation of chemical reactions between lytic and the aqueous medium.

Keywords: Levels of U, Th and K; Gamma spectrometry; Energy flow

I. INTRODUCTION

The radioactive decay of isotopes U,Th,K) constitute a portion of the heat generation on Earth. When these disintegrating elements emit subatomic particles, which are absorbed by the surrounding matter. The kinetic energy of these particles is then transformed into heat. The slow, continuous movement of plate tectonics, the formation of mountain ranges, with associated tectonics and magmatism are closely related to the redistribution of land internal heat (MURPHY; NANCE, 1992); (COFFIN; ELDHOLM, 1993); (VAN DER VOO, 2004). The elements K, U and Th are present in rocks in certain minerals and trace elements content in the various lithologies can provide additional data on the chemical characteristics of the rocks. mineralogy rocks essentially characterized by quartz and plagioclase have low concentrations of K, U and Th as the rocks composed of micas, feldspar and accessory minerals such as zircon, monazite and apatite, contain higher levels of these elements. There is thus a growth of K, U and Th with increasing silica content in the rock, with felsic rocks having higher values than those of the basic rocks. (SAPUCAIA et al., 2012). Natural radioactive elements originally occur in igneous rocks, which by weathering and sedimentary processes are accumulated in sedimentary rocks. Limestones have low radioactivity, which may even be zero, depending on their diagenesis. Unlike potassium evaporites that are sedimentary rocks that have higher amounts of radioactivity followed shales and shales, since these are derived from the decomposition of feldspars and micas (potassium-rich), and the uranium retention in the clay. (FRANZINI, 2010).

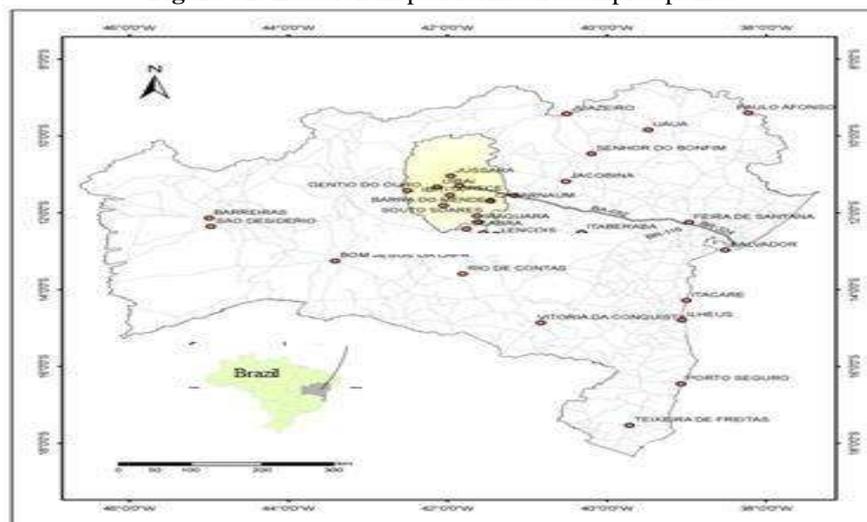
The properties of minerals and rocks, which control the storage and transport of heat in the earth are referred to as thermal properties. These, in turn, are substantial in geothermal research and geotectonic, the exploitation of natural resources and geotechnical studies and environmental geophysics. This research was conducted in the north central portion of the State of Bahia, Brazil, involving the vicinity of the river basins of the Verde and Jacaré rivers, in the fields of micro-region of Irecê (Figure 1). The geology of the region is dominated by the occurrence of Neoproterozoic covers the Craton (Supergroup San Francisco). It is a sedimentary basin with triangular filled by sediments belonging to the Una Group, which is represented from bottom to top by glacial deposits Trough training and a predominantly carbonate sequence of the Salitre Formation. The Group Una comprises an essentially carbonate sequence of the Neoproterozoic, formed the base to the top of the formations Bebedouro and Salitre. Training Trough follows the edge of the Basin of Irecê and consists of rocks of terrigenous nature deposited under glacial influence.

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major rock types are diamictite, pelitic and sandstone, with immaturity in texture and composition (GUIMARÃES, 1996; KUCHENBECKER et al, 2011; GUIMARÃES et al, 2012). The Salitre training consists of several carbonate and siliciclastic litofáceis which were deposited in shallow marine environment of the type and tidal flat, limited to each other through gradational and interdigitated contacts. Between work on carbonate rocks can mention the Sapucaia and Argollo, (2012), Nordemann and Ferreira (1992). This article presents the results of the measured concentrations of the elements K, U and Th and approaches on the radiogenic heat production rate determined in the carbonate rocks of sedimentary basin region of Irecê, Bahia, Brazil.

Figure 01: Location map of farms and sampled points.



II. METHODOLOGY AND SAMPLING

The geothermic degree is the gradient expression witness the transfer of heat toward the earth's surface. Transfer is fueled by the regional heat flow and the local production of heat due to the radioactivity of certain elements (U, Th and K). The heat flux is the amount of heat that passes through a given surface in a unit time. This flow is generally very weak, of the order of 0.2 W m^{-2} , with the exception of ocean ridges or in regions characterized by crustal thinning (KORNPROBST, 1994). The heat output (A_0) can be found by equation:

$$A_0 = \rho \cdot 10^{-5} [(9,7(U) + 2,7(Th) + 3,6(K))] \text{ W} \cdot \text{m}^{-3}$$

When ρ is the density of the rocks (density) in kg / m^3 and (U), (Th), (K) concentrations of these elements in ppm. They collected 40 fresh samples of carbonate rocks and Pb, Zn and Ba mineralized rocks, about the size of a fist. From three areas of operation of quarries placed the Irecê sedimentary basin, located on farms: San Jose, Iraquara, Palmeiras, Segredo and Melancias, situated in the range America Dourada/Umburanas. These samples were clean, properly labeled and sent to the laboratories of the Institute of Geosciences of UFBA. In Mineralogy Laboratory of Geosciences Institute of UFBA, five samples were separated and measured the density of each one, using precision scales equipped with a density meter. During this procedure the values of porosity by volumetric method were taken. These density procurement procedures carried out by means of the triple range scale, maximum load 1610g. Using the formula $D = (\text{rock-tare weight}) / (\text{weight of the rock rock-weight in water})$. The results are shown in Tables 1, 2, 3, 4 and 5. The contents of U, Th and K were measured in Classical Methods Laboratory of IGEO UFBA obtained by using gamaspectrometry (Geophysical Equipments and Services), calibrated according to the standards of the manufacturer and taking standard references mineralized samples of uranium from Lagoa Real Uranium Minel, Bahia, Brazil. The product provides potassium content in percentage, and thorium and uranium, respectively ppm, and its measurement time for each sample was 180 s. five measurements were made for each one of the samples, and then calculated the arithmetic mean, aiming to find the most likely value, so decreasing the experimental errors. When a discordant value was found, (much higher or lower than average scores) was rejected, and remade measure.

The calculation of heat generation is expressed in Table 6, and were obtained by applying the aforementioned empirical equation. The uncertainty associated with each measure was due to possible random errors that result from small independent and uncontrollable errors. As an example, the estimate was made on the read data, or small variations of the measured compared to the sensitivity of the experimental arrangement.

III. RESULTS

Tables 1, 2 and 3 and 4 show the measured values of U, Th and K through gamaspectrometry in samples of São José, Iraquara Farm, Palmeiras, Segredo and Malancia, respectively. The values of the density of samples of carbonate rocks and mineralized carbonate rocks are shown in Table 5. The U content, Th and K in the Fazenda São José Iraquara present average levels in the vicinity of 1.66 ppm U, 12.00 ppm Th and 10530.0 ppm K. for Palmeiras Farm average levels of 1.82 ppm U, 12.2 ppm Th and 9945.0 ppm K. for Farm Segredo average levels of 2.24 U ppm, 11.68 ppm Th and 9950.0 ppm K. for Farm Malancia average levels of 1.84 ppm U, 12.50 ppm Th and 9480.0 ppm K. the density with average values of 2.96, 2, 7080, 2.79, 3.01 to Fazenda São José Iraquara, Palmeiras, Segredot and Malancia, respectively. Applying equation 1 Kornprobst (1994) there was obtained the values of $1.10 \pm 0.16 \text{ W m}^{-3}$ $0.97 \pm 0.33 \text{ W m}^{-3}$, $1.00 \pm 0.31 \text{ W. m}$ $31.03 \pm 0.23 \text{ W m}^{-3}$ for the San Jose Iraquara Farm, Palmeiras, Segredo and Malancia , respectively.

Table 1: Levels of U, Th and K in ppm on the fSão José Iraquara farms.

Sample	K	U	Th
1	9800	1,80	12,005
2	10300	1,79	11,720
3	9775	1,60	12,790
4	11375	1,81	10,970
5	11400	1,30	12,520
Average	10530,0	1,66	12,00
Standard deviation	$8,1 \times 10^2$	0,22	0,71

Table 2: Levels of U, Th and K in ppm on the Palmeiras farm.

Sample	K	U	Th
1	8550	2,96	11,875
2	10500	1,54	13,277
3	10000	1,47	10,630
4	10575	1,66	12,532
5	10100	1,46	12,750
Average	9945,0	1,82	12,2
Standard deviation	$8,1 \times 10^2$	0,64	1,0

Table 3: Levels of U, Th and K in ppm on the Segredo farm.

Sample	K	U	Th
1	8850	3,435	10,527
2	10450	1,860	12,027
3	10575	1,679	11,960
4	10050	1,930	12,272
5	9825	2,282	11,622
Average	9950,0	2,24	11,68
Standard deviation	$6,8 \times 10^2$	0,70	0,68

Table 4: Levels of U, Th and K in ppm on the Melancias farm.

Sample	K	U	Th
1	9425	2,235	12,602
2	10125	1,532	13,852
3	10150	1,345	12,357
4	9300	2,055	12,282
5	8400	2,060	11,430
Average	9480	1,84	12,50
Standard deviation	$7,1 \times 10^2$	0,38	0,87

Table 5: Density (kg / m^3) of samples from all farms.

Amostra	São José Iraquara	Palmeiras	Segredo	Melancias
1	3,00	2,707	2,673	2,99
2	2,84	2,711	2,660	3,22
3	2,85	2,712	2,674	2,69
4	3,16	2,701	3,170	3,30
5	2,95	2,710	2,780	2,87

Average	2,96	2,7080	2,79	3,01
Standard deviation	0,13	0,0044	0,21	0,25

Table 6: Heat production ($W. m^{-3}$)

São José Iraquara	Palmeiras	Segredo	Melancias	Média	
1,10 ± 0,16	0,97 ± 0,33	1,00 ± 0,31	1,03 ± 0,23	1,03 ± 0,30	

IV. DISCUSSION

From the values of the concentrations of the elements K, U, Th samples obtained by gamaspectrometry method, the measured and calculated densities using the empirical formula in Kornprobst (1994), was obtained heat production values, which are the recommended number range Shon (2014). It was concluded that the differences between the densities of the samples affected farms in the values of heat output. The samples with the highest density were from the Farm Malancia. These samples have important content of galena, barite and occasionally blende. The presence of these minerals corroborates the fact that they have been measured higher levels of U content, Th and K. The calculation of the heat production is directly linked to mineral content. Samples of Palmeiras Farm are not mineralized, behaving like ordinary carbonate rocks and thus express lower heat flux measured universe. Previous results obtained on 10 limestone samples from various regions of the globe (Nordemann, 1966) showed uranium levels from 0 to 6.5 ppm, and thorium content between 0 and 5.6 ppm. According Gascoyne (1982), have calcareous uranium content of about 2 ppm and little or no thorium (0 to 2.4 ppm), the ratio Th/U of less than 1. The rations Th/U of Irecê calcareous rocks HAVE VALUES OVER 1,0.

V. CONCLUSIONS

The question of the possibility of using gamaspectrometry methods under calcareous rocks was one of the essential objectives of this research. The obtained numerical results of Th, K and U that allowed the application of empirical equation Kornprobst (1994) and thus obtaining the approximate rate of heat production in the Irecê sedimentary basin, confirms the use of this analytical method. From the gamaspectrometry method was obtained for the basin of Irecê heat rate values of the order of $1.03 \pm 0.30 W. m^{-3}$. It was found the relationship between the concentrations of uranium, present in samples of lower density, and lower values of the measured heat flow. Finally, the values of the rate of heat flow in the Irecê region may serve as a reference for the hydrogeochemical modeling, as provided reference numbers, the fundamentals of the energy needed to start the chemical reactions between the lytic medium and watery.

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