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DATING BY THERMOLUMINESCENCE 127 POTTERY FRAGMENTS COLLECTED FROM 4 ARCHAEOLOCAL SITES IN TAQUARI VALLEY, RIO GRANDE DO SUL STATE, BRAZIL

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ABSTRACT

127 fragments of pottery from excavation of four archaeological sites in Taquari Valley, close to Lajeado, State of Rio Grande do Sul, Brazil have been dated by thermoluminescence. After usual crushing, sieving, immersing in HCl solution and then in HF solution, accumulated dose, Dac, (or equivalent or paleodose) has been measured using additive method. The annual dose rate of natural radiation was estimated from uranium, thorium and potassium content in both soil from where these fragments have been collected and in fragments itselves. Cosmic ray contribution was added. The interesting finding is that the glow curves of quartz grains from sites enumerated 101, 110 and 114 indicated rare variety of quartz known as redish quarts, whereas the glow curves of quartz grains, from the site numbered 107 are equal to these of usual quartz (hyaline). Results of dating and the properties of redish quartz will be discussed.

1. INTRODUCTION

In the last decade thermoluminescence dating has been developed for use on archaeological material, principally pottery, that was heated in antiquity [1]. Thermoluminescence (TL) is the light emitted by a material when heated and which results from a previous dose of radiation. In the simplest cases the light intensity is proportional to the radiation dose and can be used to calculated an age. In the case of pottery the event being dated is the last heating of the material to a high temperature, typically 500 °C.

Local anthropologists archaeologists believe that first settlers in southern Brazil did not arrive before 9th century; these settlers were Guarani Indians with knowledge of how to produce ceramics. Fig. 1 shows the location of four archaeological sites in Taquari Valley, State of Rio Grande do Sul. The dating procedure is described and some results are presented.

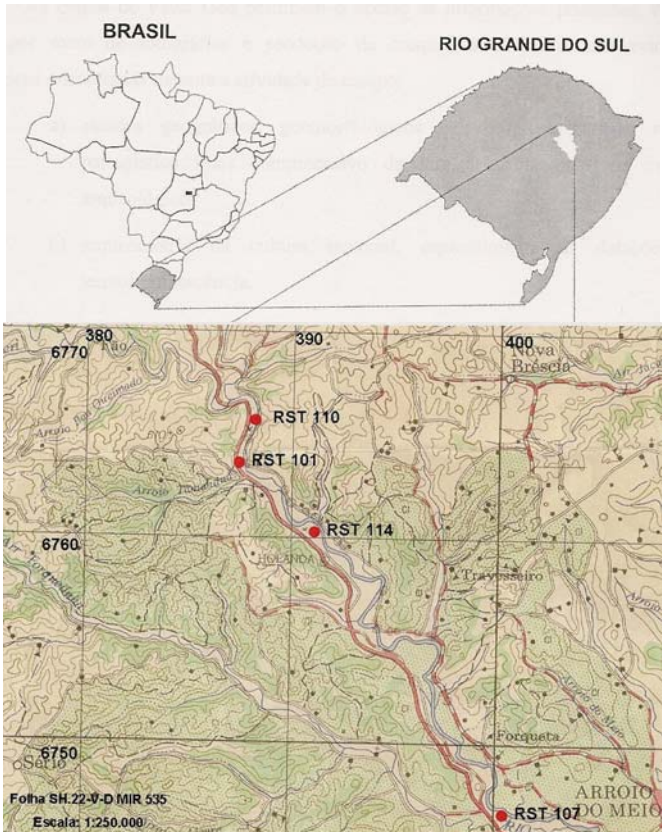

Figure 1. Brazil, Rio Grande do Sul, Taquari, Valley and sites RST101, RST110, RST114 and RST107.

2. MATERIAL AND EXPERIMENTAL

More than 100 fragments of ceramics and soil sediments have been collected for dating as well as for dating as well as for chemical analysis to find concentration of chemical elements. Fig. 2 shows some examples of ceramics.

Figure 2. Pottery fragments from Taquari Valley.

Initially, the surfaces of a pottery fragment is rubed with sandpaper to remove less than or about 1.0 mm of surface layer. Since this layer has been subjected to several external action and will certainly effect our measurement interest. This piece is then crushed with care into powder. At this point, this powder is subjected to:

a) H_2O_2 treatment to remove organic material as betas possible.
b) It is then washed in a 37 % solution of HCl, mainly to remove Ca compound. It is then washed in a distilled water.
c) The following treatment in a 20 % solution of HF has two purposes; one is to reduce the presence of feldspar; sound due to surface correction reduce greatly the effect of α-rays, about which we will talk about later.
d) Sieve such that only grains between 0.080 and 0.180 mm are retained.

Let us recall that in a dating experiment two parameters have to be determined. One is called accumulated dose, D_{ac}, also known as paleodose or equivalent dose; the other is the annual radiation dose rate, D_{an}.

The accumulated dose, D_{ac}, is the radiation dose with which the pottery fragment underground has been irradiated and, the annual dose rate, D_{an}, is the dose delivered by natural radiation per year. Then the age of fragment is given by:

$$\text{Age}=D_{ac}/D_{an} \quad (1)$$

This is age is calculated from the time the clay mold is heated to high temperature to produces the ceramics.

The accumulated dose can be determined by a method called additive method or also by a regerative method. In the additive method, the sample is divided into eight to ten aliquots; these are then irradiated to gamma-rays dose from 0, 10, 15, 20, 25 and 30 Gy. The TL output is measured and pltted as function of dose. The extrapolation of the curve (or straight line) to dose-axis gives the D_{ac}-values.

For Dan-value, there are several methods. We used ICP-MS mass spectrometer to find U-238, Th-232 and K-40 concentration, and from these value using, for example. Tabela 4.5, p. 112, in Ikeya [2], D_{an} is estimated.

For TL measurements, Daybreak model 1100 was used, with heating rate of 4 °C/s.

3. RESULTS AND DISCUSSION

For each pottery fragments glow curves of irradiated aliquots are registered. As example, in Fig. 3(a) for sample #2517.101 and in Fig. 3(b) for sample #446.107 are shown their glow curves. Firstly, the numbers 101 or 107 in each sample like #2517.101, indicate the archaeological site from where this sample was collected. Secondly, most of pottery fragments from sites 101, 110 and 114 have glow curves to these in Fig. 3(a), whereas all those from site 107 have glow curves like those in Fig. 3(b). These results tell us that the quart grains from 101, 110 and 114 behaves in one way, while those from 107 have different glow curves; actually, quartz found in any place; those from 101, 110 and 114 show glow

curves similar to that of so called red quartz, see Farias and Watanabe [3]. From the site 107 to the others these is a distance of not more than 40 km, nevertheless, it is interesting to note that the quartz grains in one site behaves differently from those found in other site. In a separate paper we will report the result of investigation of properties of these two group of quartz grains.

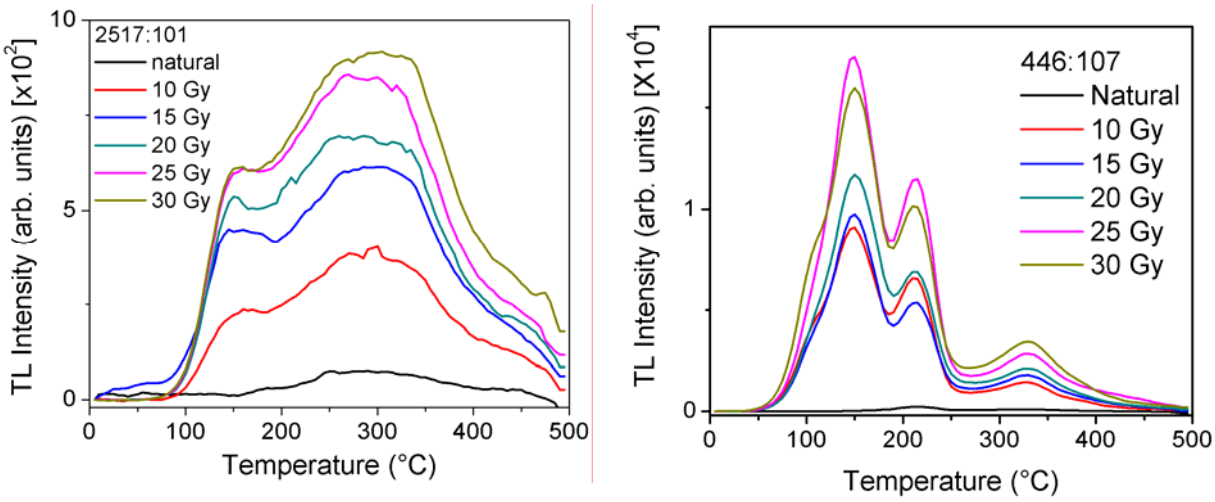

Figure 3. (a) Glow curve of the sample 2517:101 and (b) that of 446:107.

To obtain the accumulated (or paleo) dose, dac, Values, the additive method has used, assuming that below 20 to 30 Gy the TL intensity vs. dose obeys the equation y= Is(1-exp(-(D+D_{ac})/b)), were Is is the saturation value, β is heating rate. Fig. 4 (a) for the sample 2517.101 and Fig. 4 (b) for the sample 464.101 show experimental points fitted with the above equation.

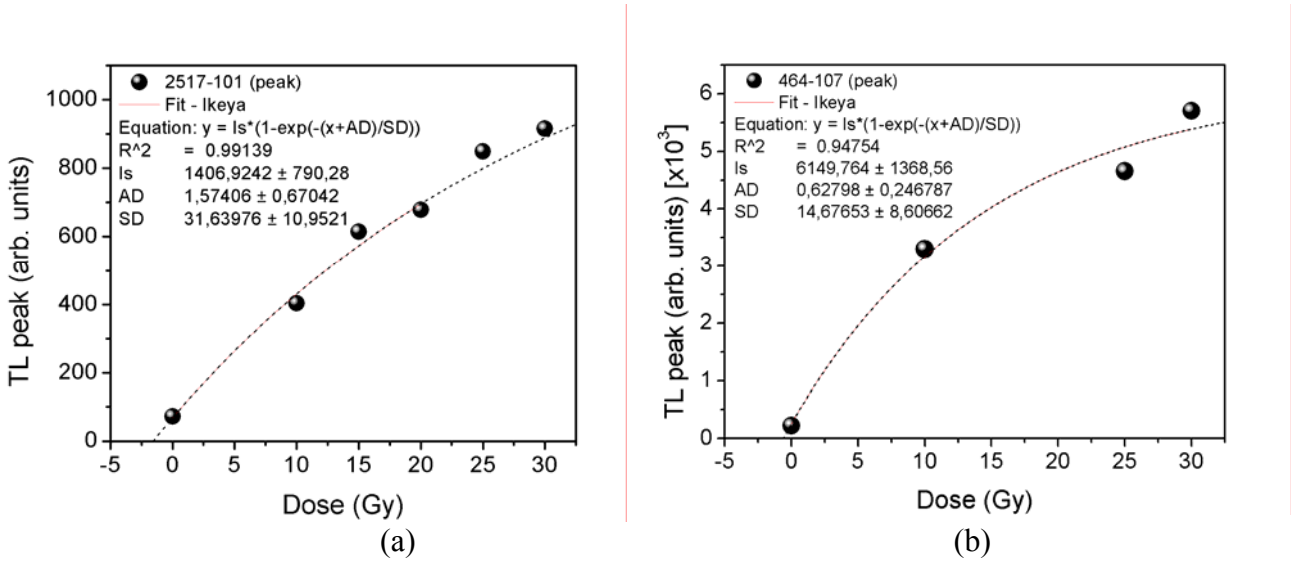

Figure 4. (a) and (b) - Additive method applied to the samples 2517:101 and 464:107, respectively.

Table 1. Presents dating results for ceramics from RST101 and RST107. The results for two other sites were not included. Annual dose rates Dan have been calculated from U, Th and K contentnts.

Sample	Dac (Gy)	Dan (mGy)	Age (years)
2512-101	1.9117	2.876	666
2517-101	2.3358	2.4097	969
3065-101	1.9226	1.88	1022
3094-101	0.3640	2.497	145
3124-101	3.1271	2.849	1097
3154-101	2.8074	3.281	855
3174-101	2.0573	3.281	627.1
446-107	0.9627	1.352	712
448-107	1.0275	1.88	546
464-107	3.9347	1.061	3708
634-107	0.7119	1.211	587
636-101	1.0113	1.376	735
659-107	0.8495	2.409	352
2181-107	0.6634	2.497	265
2183-107	0.9708	2.497	388
2200-107	0.8252	2.735	301

4. CONCLUSIONS

The obtained ages indicate that they are compatible with the anthropologists theory, namely, they are younger than 1000 years. The quartz grains extracted from ceramics from RST101, RST110 and RST114 have different TL behavior (glow curves) compared to that of grains from RST107; these last ones have the same behavior of the usual α- quartz, whereas, that of the three former quartz grains is similar to that of red variety of quartz. Below 20-0Gy, TL vs. Dose obeys the equation $y= Is(1-exp(-(D+D_{ac})/b))$, therefore for doses smaller than 5 Gy a linearity between TL intensity and dose is observed, not Aitken supralinearity.

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