International Journal of Luminescence and Applications (ISSN: 2277-6362)
Vol. 5, No. 1, February 2015. Article ID: 069. pp.118-120.

Dating of the Terrace of Thongjaolok River (Manipur, India) using Thermoluminescence Technique

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Abstract— *Thermoluminescence (TL) dating technique was applied to the quartz extracted from the sediments of the terrace of Thonjaorok River, Manipur, India. The age of the quartz samples at a depth of 8 ft. is found to be about 14,800* $\pm$ 380 *years. Study of this terrace dating should contribute a great to the understanding of geomorphology and archaeology of the Bisnupur Valley of Manipur.*

Keywords— *Thermoluminescence, Dating, Geological time, Trapping parameter, Paleodose.*

1. INTRODUCTION

Luminescence dating is a leading technique for a large spectrum of Quaternary dating applications such as reconstruction of past events and processes. This dating technique was originally developed in 1960's and early 1970's for determining the age of ancient ceramics [1 – 6]. The phenomenon used was thermoluminescence (TL) i. e. the light emitted by a sample when it is heated. Wintle and Huntley [7 – 8] were the first to present a workable TL dating technique for determining the time of deposition of sediments.

Over the geologic time, ionizing radiation from the decay of naturally occurring radioisotopes (^{232}Th, ^{238}U, ^{235}U and their daughters, ^{40} K and ^{87} Rb) and from cosmic rays liberates charge carriers (electrons and holes) within silicate mineral grains. The charge carriers can subsequently become localized at crystal defects leading to accumulation of a 'trapped' electron population. Recombination of the carriers results in photon emission i.e.luminescence. The intensity of luminescence produced is proportional to the number of trapped charges and thereby the time elapsed since deposition of the mineral grains. Experimentally thermal or optical stimulation can be employed to liberate trapped charge and this produce TL or OSL respectively.

The number of trapped electrons is a measure for the total dose- the palaeodose or the archaeodose (the total amount of energy absorbed from the ionizing radiation) the mineral has received over a certain period of time. If also the rate is determined by which the mineral has been absorbing the dose – the annual dose, this period of time (i.e. an age) can be determined from the well known equation [9].

$$Age\ (ka) = \frac{Equivalent\ Dose\ (Gy)}{Dose\ Rate\ (\frac{Gy}{ka})} \quad (1)$$

The paleodose or the archaeodose is a combined dose, resulting from exposure to α, β and ϒ radiation and thus it cannot be measured directly. Therefore, it is determined as an equivalent dose, i. e. the amount of artificial dose delivered by irradiation in the laboratory that induces a luminescence signal identical to the natural one in the sample. The annual dose is derived by calculation based on the estimation of environmental nuclide concentrations.

Among the established methods for determination of equivalent dose the additive dose method has been employed for prolong. This method involves extrapolation of the growth curve of the luminescence signal as a function of radiation added in the laboratory to the aliquots containing natural dose. [10].

This paper attempts to determine the age of the Thongjaolok River of the Bishnupur District of Manipur, India by TL technique. As terraces can provide a framework for modelling the fluvial incision as a part of landscape evolution [11] , the study of the age of this river is of greater interest and will be helpful in reconstructing the environmental and the climate change of the Bishnupur Valley of Manipur.

2. EXPERIMENT

2.1 Sample Collection

Suitable terraces are traced in the field area of Thonjaolok River at Bishnupur District of Manipur (India), ranging in the elevation from 6 ft. to 20 ft. above modern flood plain. Each terrace consists of ~ 1-4 feet thick gravel capping a strata surface eroded into sandstone bedrock. We have marked and labelled these strata from lowest to highest. Samples were collected from homogeneous sandy layer in

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metal pipes under dark room like conditions, at a depth of 8 ft from the top of the upper layer. A view of the Thongjaolok River at Bishnupur where samples are collected a is shown in Fig. 1.

Fig. 1: A view of the Thongjaolok River

2.2 Sample Preparation

The preparation of samples took place under subdued red light conditions. Sand sized grains ~ 80 – 150 μm were extracted from the sample by washing with water and sieving. Then, the samples were treated with 30% H_2O_2 and 10% HCl to remove organic and carbonates compounds present to the samples. Finally they are treated with 40% HF for about 50 minutes to dissolve feldspar grains and to etch the alpha - exposed outer rim of grains. This yields quartz extract for TL measurement.

2.3 Measurement

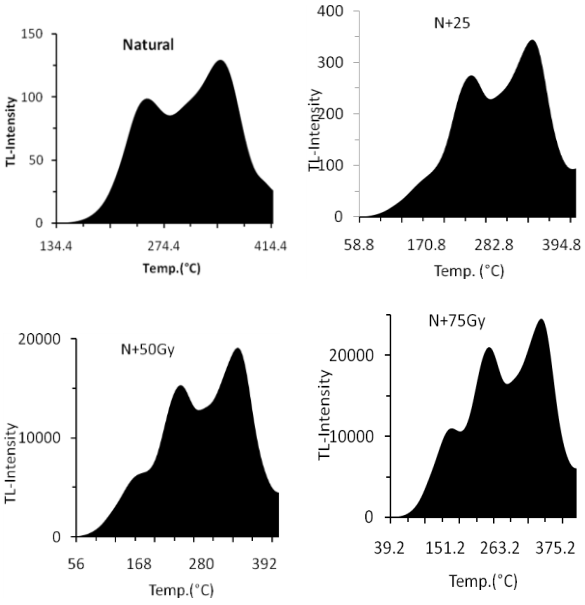

Fig. 2: Natural TL (NTL), N+25Gy , N+50Gy and N+75Gy, γ-irradiated glow curves of quartz extracted from the samples of the terrace of Thonjaorok River.

All TL glow curves of the quartz sample of Thongjaolok river were recorded using TL reader, Model 1009I (Nucleonix System Pvt. Ltd. Hyderabad, India) at Luminescence Dosimetry Laboratory, Thoubal College, Thoubal. The heating rate used was 5^0Cs^{-1} with the temperature set from room temperature to 500^0C. A second readout was performed to record the background radiation, which includes the black body radiation. The data presented are all with the background subtraction. The samples were γ-irradiated at Life Sciences Department, Manipur University, Canchipur. Imphal. Both natural TL (NTL) as well as N $+\gamma_i$ glow curves were recorded with a pre- heat of the sample up to 175^0C to remove bleachable lower temperature glow peaks.

3. RESULTS AND DISCUSSIONS

Luminescence dating is uniquely suited to assist in the task of deciphering the depositional history, chronostratigraphy and climate evolution recorded in the sediments of river terraces. One of the natural TL glow curves of the quartz sample of the Thongjaolok river along with glow curves of the Natural (N) +25 Gy, N +50 Gy, N+75Gy i.e. N+ γ_i are also presented in Figure 2. The sample was exposed to sunlight for two days. This causes bleaching of the geological TL of the sample to a residual value G_0 [12]. Figure 3 shows the dose response curve (DRC) of the sample and the equivalent dose (ED) is calculated by extrapolation up to the horizontal line through residual value G_o. The value of G_0 is found to be about 1 Gy. Using the dose rate 2.47 Gy/Ka [13] of the region the age of the sample is determined by using the equation (1) and is found to be about 14,800 ± 380 years in average indicating that the sample was belong to a period of about 12,800 B.C.

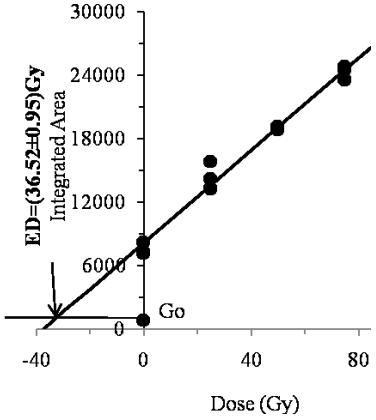

Fig. 3: Dose Response Curve for the samples collected from the terrace of Thonjaolok River.

4. CONCLUSION

The age of the sample collected at a depth of 8ft. from the top surface of the river terrace of Thongjaolok river,

determined by TL technique using additive dose method were found to be 14,800 ± 380 years. The study of the terrace of the river will be helpful in understanding the site formation processes of these sedimentary deposits and to reconstruct the environmental and the climatic change of the Bishnupur Valley of Manipur.

ACKNOWLEDGEMENT

The authors are thankful to AERB/CSRP, Mumbai, for financial assistance in the form of Major Research Projects and Department of Life Science, Manipur University for providing the facility of γ- irradiations. One of the authors, S. Bidyaswor Singh, is grateful to the UGC, NERO, for partial financial support in the form of a minor research project.

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