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Dating of Ancient Floods Features by Thermoluminescence in the Karoon Drainage Basin (South West of Iran)

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Abstract: These days thermoluminescence (TL) dating is used commonly for dating pottery, brick, volcanic rocks and sediments. The main purpose of this study was dating ancient flood sediments. The ancient flood method concerns the features of the floods in the past which was a safe method for controlling and avoiding coming possible floods. In this method different tools were used which were geological and geomorphological ones to identify the features of the flood. Briefly, the stages of doing ancient flood method including, selecting the drainage basin, selecting suitable area in this basin, doing field activities for sampling flood features, sending these samples to dating laboratory for estimate the age of the flood and doing statistical and hydraulic calculations. The study area for sampling flood sediments was Karoon drainage basin located in south west of Iran. TL method was used in slack-water deposits was used for dating flood sediments by taking four samples. Add conclusion of the study here.

Key words: Dating · Thermoluminescence · Ancient flood · Karoon

INTRODUCTION

Thermoluminescence dating method is one of the absolute dating methods for estimating the age of geological and archaeological samples which generally used [1] (start referencing from "1"). TL measurements are carried out on a sample of mineral material, usually a separated quartz or feldspar fraction. This is heated to temperatures in excess of 500°C and as light (photons) is emitted from the luminescence centres, the photons are converted to electric pulses using a photomultiplier tub, an instrument that is a very sensitive detector of light [2] (this reference should be [2].

Paleofloods are events generally recorded outside of gaging records, or they are historical floods that can be placed within a long-term historical or geological context [3]. Paleoflood hydrology combines a multidisciplinary approach (stratigraphy, sedimentology, geomorphology and hydraulics) in the study of past or ancient floods, to decipher, quantitatively, past flood discharges, extending the record of extreme floods from centuries to thousand of years [4]. This information can be used in risk assessment and in the assessment of climatic change on flood [5]. Historical and paleoflood data have been used to supplement peak flow estimates from existing stream gage record and to extend those records in time [6]. There has been increased interest in obtaining and using historical and paleoflood data in flood frequency analysis [7]. Paleoflood studies are based on geologic evidence of flood stages and channel geometry, which lead to the estimation of flood paleostages [8]. When the floods passing through the valleys and floodplains they leave some features behind. These features are called paleostage indicators or past flood levels indicators. The most important features of ancient floods are botanic evidence, slack-water deposits, flood scars on the trees, erosion scars, bouldery flood bars, debris flood bars, alcove and fracture deposits, terraces and cave deposits [8]. In the ancient flood surveys, mostly for estimating maximum of paleolevel, slack-water deposits are used. Slack-water sediments are fine-grained alluvial deposits that have settled out of suspension during flood events in zones of reduced flow velocity [9]. Most of these sediments are composed of silt and sand. By means of dating methods we can consider special age for any kind of feature and in this way for every ancient flood feature

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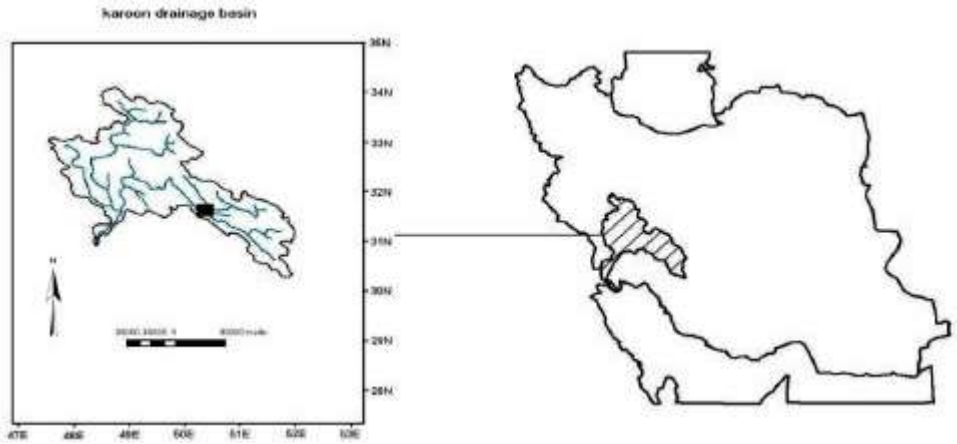

Fig. 1: Location of the Karoon drainage basin (sampling area is marked with rectangular)

we will have an age and a discharge. The result got from the ancient flood surveys are suitable supplementary data for flood-return period calculations.

Study Area: The study area located in Chahar Mahal Bakhtiyari province in south western of Iran (31°35×N and 50°24×E) (Figure 1). The selected area is near Karoon-4 dam in Dehdez village. The karoon is the biggest river in Iran. This river is considered the most important and vital projects for constructing dam and power stations. The area where Karoon located is one of the area flood happens mostly, for example we can notify the floods of the years of 1968, 1972, 1975, 1979, 1981, 1986, 1994 and 1998 that brought lot of damages in these times. The area is located in the margin of north eastern folding Zagros. The main geomorphological feature of the area is the anticlinal of Kuheh-Sefid where Karoon-4 dam is located on its south western limb.

MATERIALS AND METHODS

The common strategy of survey of ancient floods is finding the areas where the features of ancient floods still may be preserved. The indicators of the flood are commonly physical indicators, these features are the evidence for maximum level of new floods. Before doing field activities some of the information in the area such as the floods happened before and also other data such as geological, geomorphological and climatic characteristics must be gathered. The several stages of field activities in this study include doing field working for identifying the features of ancient flood and sampling flood sediments to send to dating laboratory for dating experiments which include preparing and analysis the samples and at the end estimating the age of the samples parallel with the errors of dating. The number of the samples was four and after surveying the samples we got that the samples are dateable. Because the samples were sediments, we used TL method for dating. In the beginning we selected the sampling places which are in acceptable conditions and features. These selected ranges at least should have the stable bed. For this reason we selected the stone bed to be surveyed and in another hand the range must be such long that the stream in different points under the study get the stable and developed condition. Length, width and radius of the meanders (if available) must be identified and by means of available criteria the stability of the river must be surveyed. Then in these ranges the possible amount of the features and the effects of past floods must be identified. Sampling of the features and the effects of old floods are the most difficult and sensitive part in this method, because error and mistake in this stage bring a lot of errors in calculation. For sampling the flood features first we have to find the height where the flood has passed and then we start sampling the sediments of the flood in the area. Totally for doing this study the stages are in order as follow:

- The suitable selected drainage basin for ancient flood study.
- Identifying the characteristics of the study area, such as topographical, geological, geomorphological, hydrological and climatic characteristics.
- Selecting one or several suitable range in the study area.
- Gathering geotechnical and morphological characteristics of the selected ranges.

- Doing field activities including identifying and sampling the features of the ancient flood.
- Preparing the samples for dating.
- Dating the features in the laboratory

RESULTS AND DISCUSSION

The Effects and Features Found

Slack-Water Deposits: these are the useful features for reconstructing ancient floods. These sediments mostly have light color. For dating these sediments we did sampling, the samples composed of silt and sand with lots of small organic particles. In different parts of the river these sediments are seen on the conglomerates of Bakhtiyari that in some cases with these sediments big boulders are seen too. Bakhtiyari conglomerate formation because of the heterogeneity of its composing grains were eroded and they have created suitable place for deposition of flood sediments (Fig. 2a).

The Carried Boulders: These boulders which some of them have more than 10 cm diameter in floodplain are in the forms of groups. Some of these boulders are with slack-water deposits which are available in eroded sinking of Bakhtiyari conglomerates and some of them are seen with debris flood bars. These kinds of features mostly used for estimating of discharge of the ancient floods (Fig. 2a, b).

Eroding Effects and Features: The eroded stones in the area often are conglomerates of Bakhtiyari where the eroding effects of the flood are well seen. The erosion effects often are seen in the form of continuous lines (Fig. 2-d).

Debris Flood Bars: These features include the pieces of tree trunk, bough and small timbers which are on the big boulders (Fig. 2-b).

Terrace: In the study area a lot of terraces are seen which some of their heights are more than 10 meters. There are alluvial deposits on the terraces which have almost good sorting and roundness.

Alcove and Fracture in the River Margins: These cavities in the stones near the river bank are because of the dissolution factors. The size of the cavities are more than 20 cm (Fig. 2c). Inside the cavities, the sediments which have the grains of silt to sand are seen.

The Evidence of the Sediments and Plants on the Trees: these evidence include wood, timbers and sediments on the trees and have been left after the floods. These evidence show the height of the flood.

It must be noticed that all kinds of evidence and features which show the effects of the floods will be useful and should be collected.

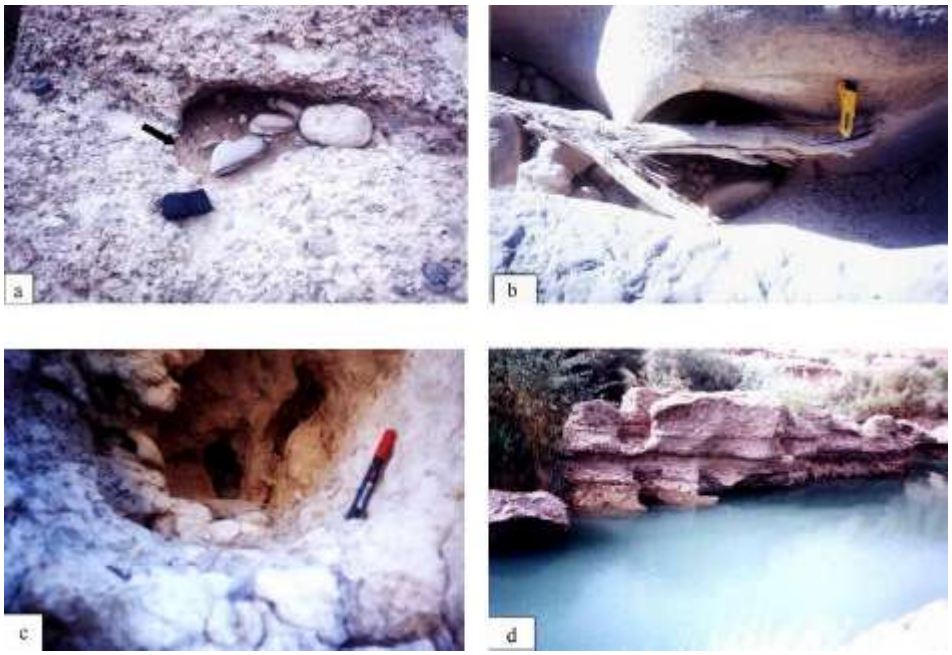

Fig. 2: Some of the ancient flood features in the study area (a: Slack-water deposits with boulders, b: Debris flood bars, c: Alcove and fracture in the river margins and d: erosion scars)

Petrography: Before analyzing the samples in the laboratory and studying them under the microscope, we prepared a section from each sample. The purpose of the petrography depends on the kind of the sample. In the case of the kinds of sediments this is used for identifying the abundance of composing minerals and also for choosing the kind of mineral for dating analysis. Because the kind of mineral we choose for dating, should be abundant enough so in this case we can extract enough amount from sample. For this we prepared one section from each kind. Petrography of the samples include surveying of the sections under the microscope and preparing pictures of them.

Because the study area is composed of calcareous formation, the earned samples often include calcite. Quartz is the second composing mineral in term of abundance (specially in the sample SW4) and for this reason we choose quartz for analyzing of dating. In the dating method of thermoluminescence often quartz mineral is used, because either it is found abundantly in all the sediments or quartz mineral unlike other minerals such as feldspar and calcite shows only one peak in measuring of intensity of TL that it has the less error. In addition with quartz and calcite, other minerals such as feldspar and mica (which often are seen in the samples of SW1 and SW2) and grit are seen in the samples too. In the sample SW3 more organic particles are seen compare with other samples.

Separating and Preparing the Samples: For extracting the sample, first we put a little amount of the raw sample in the mortar and rub slowly to separate the parts that are together. After we have the sample in complete powder for, we put little amount in the test tube and add six cm acetone liquid on, then we wait two minutes. According to stokes × law, the particles bigger than 10 micron deposit in two minutes and the particles smaller than 10 micron remain floating in the liquid. We empty the floating sediments on the liquid to the beaker and we repeat it several times until at least we have 35 grams of the sample which is necessary for measuring TL signal. After getting the needed amount, the beaker that has the particles from 1 to 10 micron was set in the centrifuge from 5 to 10 minutes to make the particles set down fast. Then we set the tube which has the sediments in the ultrasonic bath to separate the glomerate and adherent particles. At the end we add acetic acid, 5% to the sample for destroying the non-pure materials except quartz including feldspar, carbonate and organic materials. Then we put the sample in a completely dark place and out of light for some days. After that the sample dry completely, we add some acetone and mix it well to expand the quartz equally in all parts of the liquid. For measuring the intensity of TL, the solution is set on the circular aluminum foils with the diameter of one cm to make the particles deposit. First we put the aluminum foils in the acetone liquid to destroy the non-pure materials. Then we dry these foils and rub with the sandpaper to create lines on the papers. Because when we put the foils in the furnace with the temperature of 400 to 500°C the lines on them totally destroyed and becomes completely flat. For depositing the samples, these aluminum foils must be striated till the solution deposited well on them that is why we make some lines on the aluminum foils with sand paper. Then we set the foils in the acetone in the beaker and for five minutes we put it in the ultrasonic bath to destroy the materials created with the sandpaper. In the next step we put each of these foils in the test tube with the acetone and we add one ml of the solution which includes the particles of quartz with the dropper. We set these tubes in the special place for some days to have the complete sediments of the solution on the foils. Then the sample on the foils should be completely dry and in this stage the sample will be ready for measuring the intensity of TL. we do these stage for all the samples. This method of separating is called fine grain that in which we separate the particles in the size of fine sand to coarse silt.

Preparing and measuring of the samples were done under the red light to prevent the possible effects of the normal lights.

Measuring Equivalent Dose: For preparing, the samples after powdering become etching with acetic acid, 5%. From each sample, at least we made 50 tablets. For 15 tablets after putting in the furnace on the paper from chromium-nickel alloy in pure nitrogen environment, we measured the glow curve. In the next stage 30 tablets were irradiated in different doses by beta source with strontium 90 isotope. Half of the samples measured two days after irradiating and another half after two weeks, to survey on the phenomena of losing fading. In the next stage 15 tablets were irradiated in different doses by alpha source with the isotopes of americium 241(Am-241). By measuring them, the measure of effective energy of alpha and the sensitivity of samples toward alpha radiation were measured. By comparing primary glow curve (natural TL curve) and irradiated glow cure with beta radiation, we calculated the measure of the stored energy (ED) in the sample.

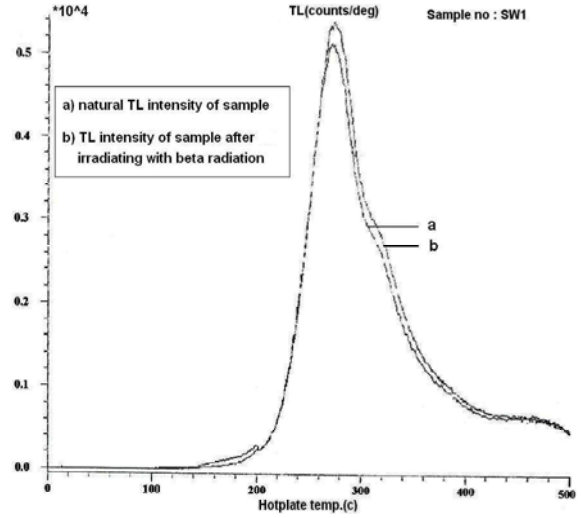

Fig. 3: Curve of measuring intensity of TL (sample no: SW1)

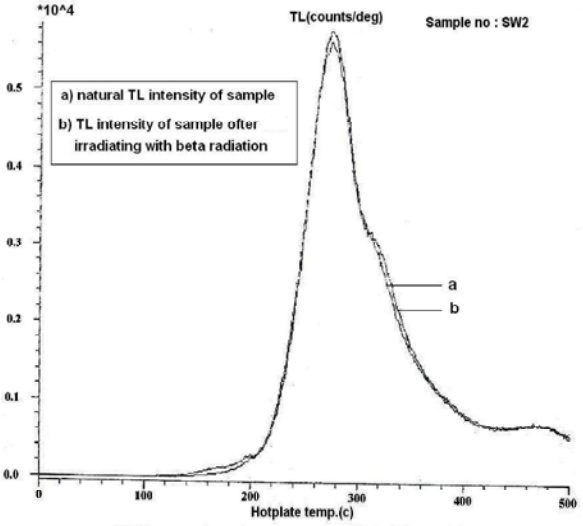

Fig. 4: Curve of measuring intensity of TL (sample no: SW2)

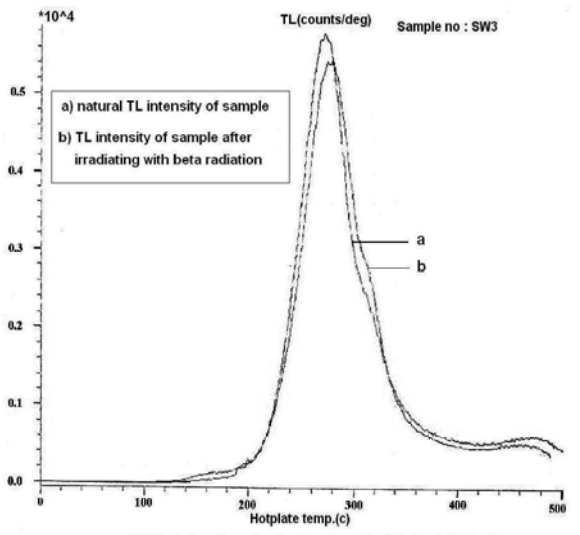

Fig. 5: Curve of measuring intensity of TL (sample no: SW3)

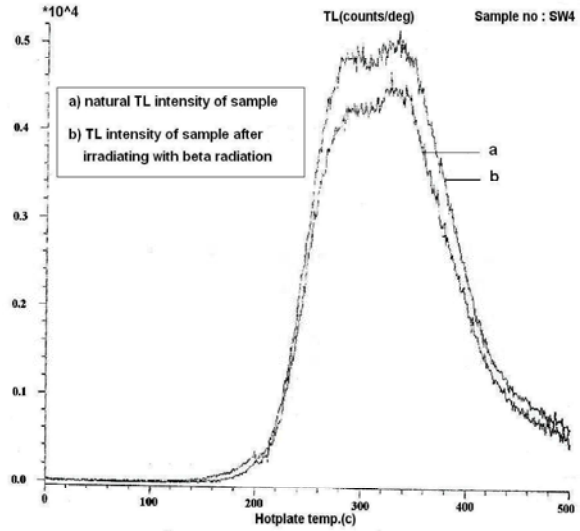

Fig. 6: Curve of measuring intensity of TL (sample no: SW4)

Measuring Unbleachable Residual: for measuring unbleachable residual 15 samples was considered. These tablets exposed the sunlight in different time and then received beta radiation with different doses. It is observed that the samples got into to unbleachable residual maximum in eight hours. The measure of the remaining energy in the crystals after the maximum exposure by the sunlight can be measured and reduce it from the equivalent dose and the last exposure of the samples with the sunlight can be observed. Age calculated for each sample is exactly the last time that samples were exposed to the sunlight.

Measuring the Concentration of the Radioactive Elements in the Samples: Accuracy of dating experiment directly depends on exact estimating the measure of the radioactive elements in the sample and therefore measure of the annual energy stored by these elements in the sample. It is needed to measure the concentration of the elements such as Potassium, Uranium and Thorium in the sample. The concentration of Potassium was measured by the method of the wet chemistry in the laboratory of Geology Organization and the concentration of Uranium and Thorium was measured by alpha counting method in the Conservation and Rebuilding Research House.

Table 1: dating results of samples

Sample no	U concentration ppm	Th concentration ppm	% K_2O concentration	Equivalent dose (Gy)	Annual humidity (%)	Cosmic rays mGy/a	error±age years
Sw1	5.81	5.93	1.12	34.39	0.65	0.15	1420±85
Sw2	6.91	4.35	1.92	23.96	0.65	0.15	880±50
Sw3	4.05	2.96	0.92	27.90	0.65	0.15	1390±70
Sw4	5.19	4.06	0.54	27.13	0.65	0.15	1350±85

Dating the Samples: After separating and preparing the samples, we did the experiments for measuring the equivalent dose. Since the samples had lost their humidity during sampling, for measuring the relative and absolute humidity of the samples we used the data of Meteorological Organization. Also for measuring environmental dose we used the data of Atomic Energy Organization. For measuring equivalent dose we used drawing regression between the curves of natural and irradiated curves with beta rays. Measuring the errors include measuring both accidental and systematic errors. Dating results of the samples with measured parameters and curve of measuring intensity of TL are shown in Table 1 and Figures 3-6.

CONCLUSION

By dating methods we can attribute special age for flood features. The old discharge of the flood is calculated by using special features (such as slack-water deposits). The results by these measurements include the age and discharge of ancient flood which give suitable supplementary data for calculating returning period of the flood.

- The identified effects and the features in Karoon river show that this river has high capability of the floods. Slack-water deposits, the carried boulders, erosion scars and debris flood bars are considered important features in this river.
- For thermoluminescence dating method we used slack-water deposits. Most of these sediments are composed of silt and sand.
- For measuring the intensity of TL in dating laboratory we use just one mineral. By petrography of the samples and the survey under the microscope quartz mineral was chosen for these analysis. The samples made ready with fine-grain method and measured and irradiated with additive-dose method.
- The earned ages according to the results of dating experiments for the samples are SW1(1420±85), SW2(880±50), SW3(1390±70) and SW4(1350±85). Because the amount of the samples are less than normal, on the age of the flood cannot discuss reliably, but according to the ages of the samples SW1, SW3 and SW4 which have the similar ages, by calculating the average age of the samples the age of the ancient flood in the study area can be 1380 years old. Overall in ancient flood method the number of the samples in dating must be more than 30.

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