
Ancient TL

www.ancienttl.org · ISSN: 2693-0935

Concha, G., Roman, A., Brito, O. and Deza, A., 1980. *Thermoluminescence dating of ancient toconce potteries*. Ancient TL 4(1): 9-11. <https://doi.org/10.26034/la.atl.1980.032>

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THERMOLUMINESCENT DATING OF ANCIENT TOCONCE POTTERIES

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SUMMARY: The dating of five samples from different depth levels of the same archaeological "site" Toconce was made by TL measurements. These results agreed with the estimated values obtained by the archaeological context and the radiocarbon method.

INTRODUCTION: The study of the natural thermoluminescence (NTL) and the artificial thermoluminescence (ATL) produced by irradiation with the beta source was made on five pottery samples from the archaeological "site" Toconce at Antofagasta in the north of Chile. The pieces of pottery were chemically washed and sieved in order to get the quartz grains with a diameter of 100 microns. The radiation dose received by each sample, after its original firing, was determined by the "plateau" and the "pre-dose" methods. The annual dose was calculated from the concentration of radioactive trace elements of the sample and the burial soil. An analysis of the TL glow showed that the light emission is proportional to the dose received by the sample. The calculated ages of the five samples differ by about 10% from the values given by the radiocarbon and context methods.

METHODS AND MATERIALS: The quartz grains, were poured onto a stainless steel sample holder, and placed on a heater plate. The heating rate of 20°C/sec was controlled electronically and measured with a chromel-alumel thermocouple welded to the heating plate. The luminescent emission was detected with a photomultiplier (Phillips 56-AVP) connected to a high tension source (Keithley 246). The signal from the photomultiplier was amplified with an electrometer (Keithley 610 c), and recorded through channel Y of a Hewlett-Packard 7004-B recorder. The signal from the thermocouple was recorded through channel X of the same recorder giving the glow curve. The quartz grains were irradiated with a 85 rad/min dose rate from a fixed position Sr-90, 10 mCi source.

SAMPLE PREPARATION: The pottery samples were crushed and washed with "Aqua regia" and 1% HF solution. The quartz inclusions were sieved to obtain grains with 100-200 microns diameter in order to use the quartz inclusion technique (1).

THE EQUIVALENT DOSE (ED): The dose received by the sample after its original firing, the equivalent dose (ED), was calculated by the "plateau" and the "pre-dose" methods. In the plateau method the curves of NTL and ATL, for 850 rad β dose, were recorded.

These measurements for a particular pottery were repeated in order to obtain a mean value of the plateau. In the pre-dose method, the samples received a test dose and a laboratory dose of 850 rads. The obtained ED value is also a mean value of a serial of measurements. Figure 1, 2 and 3 show the curves obtained for two of the studied samples.

A preliminary examination of the luminescent emission, as a function of the received radiation dose was made for each dated sample. After a heating of 450° during 3 hours, the samples were irradiated from 0.5-12 min. with the Sr-90 source. The linearity existing in this zone made possible the calculation of the equivalent dose.

THE ANNUAL DOSE (D): The concentrations of radioactive trace elements in one of the pottery samples and the burial soil were determined by the Neutron Activation Analysis Department of "Comisión Chilena de Energia Nuclear", La Reina at Santiago-Chile. These concentration values are in Table I.

Table I

| | U-238 (ppm) | Th-232 (ppm) | K (%) |
|------------------|----------------|-----------------|-----------|
| Pottery (IFUC-3) | 3.8 ± 0.3 | 16.4 ± 0.4 | 1.5 ± 0.3 |
| Soil | 4.0 ± 0.3 | 13.3 ± 0.8 | 2.1 ± 0.4 |

The contribution of each of these elements to D was calculated by Aitken's method (2). Since the quartz grain diameter is about 100 microns the alpha contribution to D was neglected. The calculated D was 0.43 rad/yr. and was used for dating each sample, in spite of the fact that these were not found in the same depth level (50-100 cm).

RESULTS: The calculated dates for the Toconce potteries are in Table II.

Table II

| Sample # | ED(rads) | Method | D(rad/yr) | TL age(yrs.) | Estimated age(yrs.) |
|----------|----------|------------------------|-----------|--------------|----------------------|
| IFUC-1 | 410 | Predose and Plateau | 0.43 | 950 | 850 ± 50 context |
| IFUC-2 | 430 | Plateau | 0.43 | 1000 | 1050 ± 150 context |
| IFUC-3 | 490 | Plateau | 0.43 | 1140 | 1075 ± 75 context |
| IFUC-4 | 460 | Predose | 0.43 | 1070 | 950 ± 50 context |
| IFUC-5 | 330 | Plateau | 0.43 | 770 | 700 ± 10 radiocarbon |

CONCLUSIONS: The dating of ancient pottery by thermoluminescence measurement was made for the first time in this country. The calculated TL ages differ by about 10% from the values determined by the other methods. These results can be improved with an accurate determination of D by means of "in situ" dosimetry with CaSO_4 Dy dosimeters.

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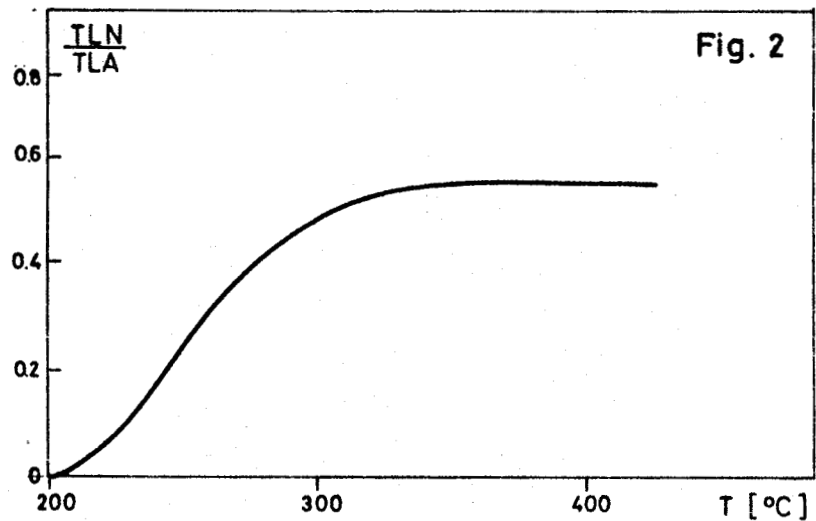
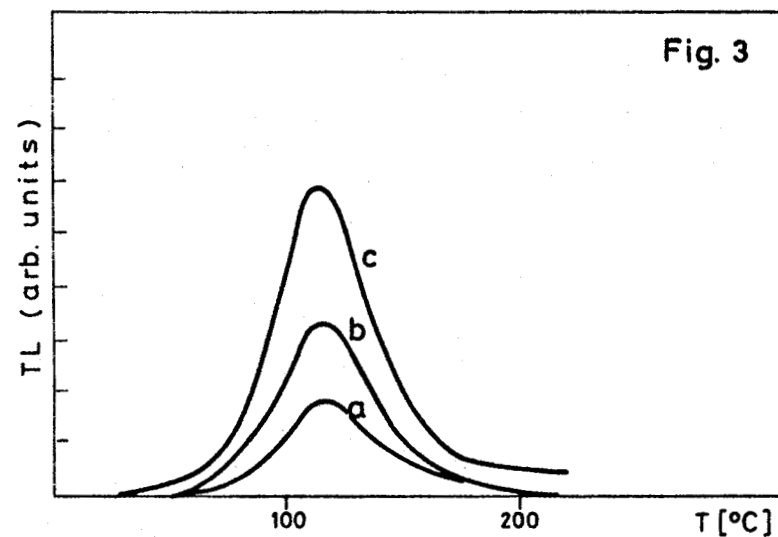
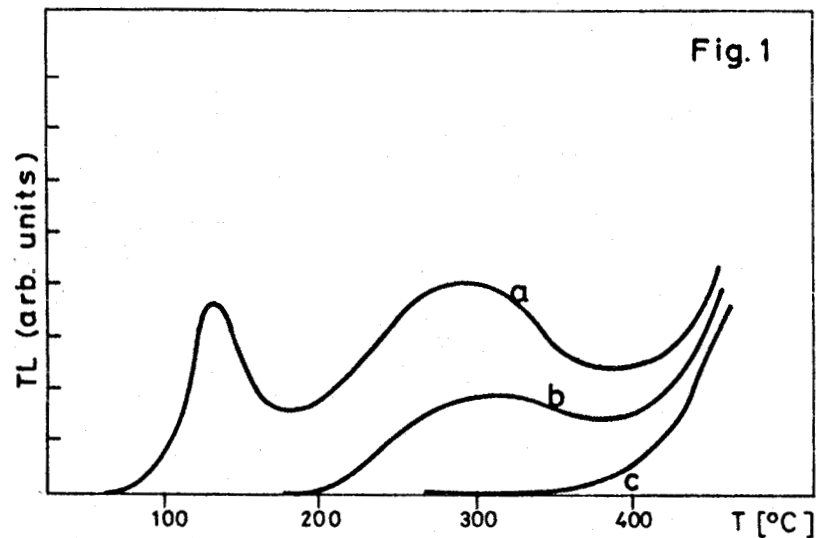


Fig. 1: IFUC-3 TL curves.

- a) ATL for 850 rad β dose
- b) NTL
- c) Thermique radiation

Fig. 2: IFUC-3 plateau test

Fig. 3: IFUC-1 pre-dose effect

- a) S_0 response
- b) S_N response
- c) $S_{N+\beta}$ response

The experimental conditions for all glow-curves were: Heating rate 20°C/min; sample weight 8 mg, and N_2 flow 4 l/min.