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Ultrathin TLD Measurement of Alpha Dose-rate and Comparison with Alpha Counting

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INTRODUCTION:

Determination of internal beta dose-rates in pottery using thermoluminescence dosimeters (TLD) has been reported (e.g., Mejdahl (1978), Wang (1982a), Bailiff and Aitken(1980)). This article describes the measurement of internal alpha dose-rates in pottery using $CaSO_4$:Tm ultrathin thermoluminescence dosimeters. Among the advantages of the technique are convenience and low cost.

METHOD:

The ultrathin $CaSO_4$:Tm dosimeters (thermoluminescence dosimeter type II) are manufactured by the Shanghai Industrial Hygiene Institute (Zhou, 1982). Phosphor is deposited onto 8 mm diameter, 10 micron thick aluminum foil to a thickness of 2 mg/cm^2. For each pottery sample twelve TLDs are annealed at 400 degrees C for five minutes then divided into two groups of six - Groups A and B. Group A dosimeters are as described above and, therefore, are alpha-shielded on only one side. Group B dosimeters have an additional top covering of foil and are, therefore, completely shielded against alpha particles.

Four dosimeters from each group (a total of eight) are embedded in a glass container of powdered pottery (fig. 1). The remaining four dosimeters are deposited in either quartz or $CaSO_4$ (both low radioactivity) to measure environmental radiation. Containers are sealed and stored in the dark for at least one month. At the end of the storage period, the dosimeters are removed, cleaned in distilled water and dried at about 80 degrees Centrigrade.

The TL of Group B dosimeters derives from beta and environmental radiation only while Group A dosimeters produce TL resulting from an additional alpha particle dose. However, since the Group A dosimeters are alpha-shielded on one side, their alpha contribution results from one-half the infinite matrix alpha dose-rate. The thermoluminescence induced by 4-Pi geometry alpha irradiation, G_α, is obtained by the equation

$$G_\alpha = (G_a - G_b) \times 2$$

where G_a is the average TL of Group A dosimeters and G_b is the average TL of Group B dosimeters in the sample. Although not rigorously correct, it is assumed in the calculation that the phosphor thickness is small compared to the alpha particle range. The alpha dose-rate, D_α, is

$$D_\alpha = G_\alpha / (\chi_\beta \cdot \varepsilon \cdot t)$$

where χ_β is the TLD beta sensitivity,

- t is the storage time and
- ε is the ratio of alpha to beta sensitivity (0.15 for this phosphor).

The beta dose-rate, D_β, for the sample can also be obtained from the measurements as

$$D_\beta = (G_b - G_c)/(\chi_\beta \cdot t)$$

where G_c is the average TL of the environmental dosimeters.

RESULTS:

The results of alpha TLD measurements on 28 samples are shown in Table 1. Also shown are the results of alpha counting measurements on the same samples using a surface barrier detector (Aitken, 1978; Wang, 1981). Measurement error is less than 7% for TLD and less than 3% for alpha counting. It can be seen that there is reasonable agreement between TLD and alpha counting in most cases. For samples showing large discrepancies the TLD results are systematically higher. Since alpha counts were performed unsealed and TLD accumulations were sealed, it is thought that these differences may result from differences in radon retention for the two methods. In the case of the pottery body itself, we have found the probability of radon escape to be less than 10% (Wang, et al., 1982b). The samples should be sealed in the containers during the TLD measurement to duplicate the situation during burial.

TABLE 1

Comparison of annual alpha dose by TLD and alpha counting

Laboratory Reference	Dose-rate (rad/yr) TLD	Alpha counting	TLD/Alpha
SML 1a	3.040	2.668	1.14
2a2	3.755	3.703	1.01
2a3	3.173	3.268	0.97
7a	2.835	2.555	1.11
7b	2.916	2.770	1.05
9a	2.067	2.156	0.96
17	2.027	2.188	0.93
19a1	2.307	2.474	0.93
25b	3.606	3.572	1.01
25c	3.594	3.099	1.16
25e	3.183	3.288	0.97
27b2	4.315	4.109	1.05
27c1	4.147	3.989	1.04
27c2	3.933	2.715	1.45
28b	4.015	3.660	1.10
28c	4.762	4.905	0.97
28d	4.751	4.479	1.06
28e	3.793	4.012	0.95
37a	5.350	5.115	1.05
37b	4.670	4.431	1.05
37c	4.662	4.289	1.09
38a	4.588	4.571	1.00
39a	6.497	6.252	1.04
39b	7.263	6.630	1.10
40a	4.720	4.802	0.98
41a	5.133	3.660	1.40
42a	2.587	2.452	1.06

CONCLUSIONS:

We have demonstrated that it is possible to measure internal alpha dose-rates in pottery using ultrathin TLD and have found the results to be in reasonable agreement with alpha counting. The TLD method has the advantages of low cost and convenience. In addition, some correction for water content and disequilibria is accomplished.

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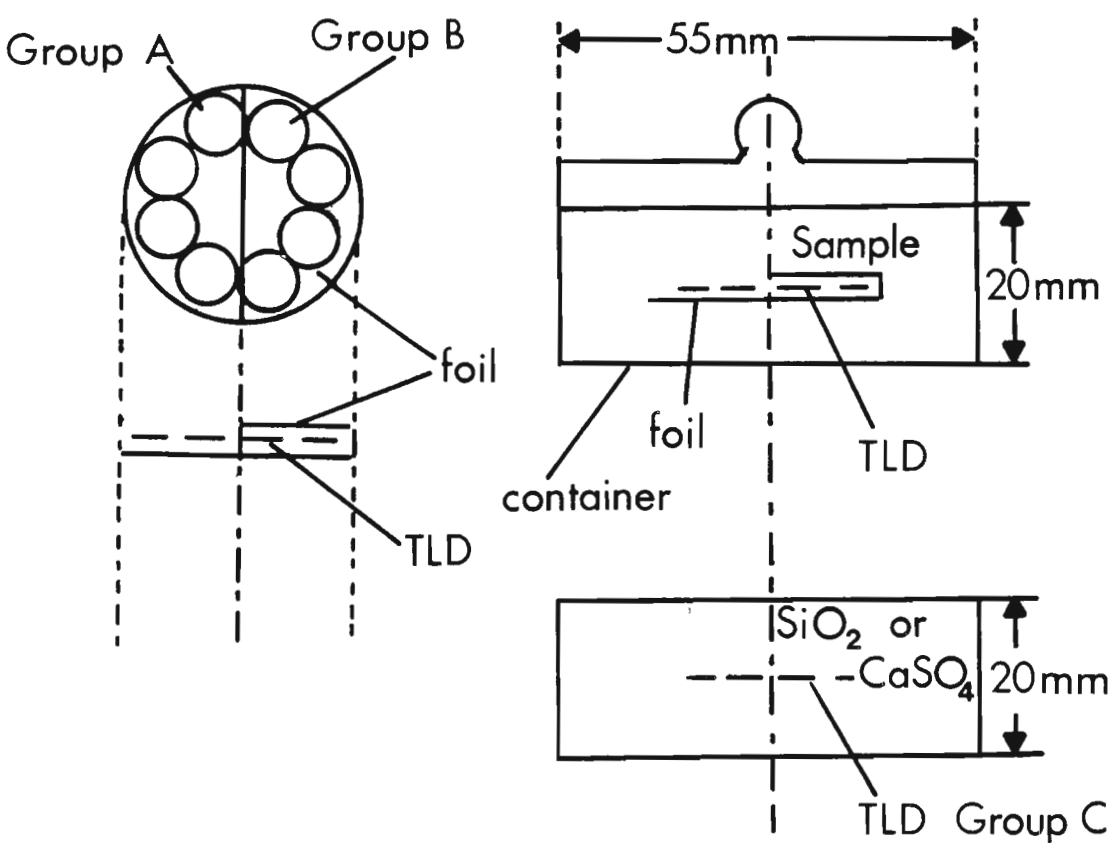
Figure 1: Irradiation Configuration for Ultrathin TLD Determination of Alpha Dose-rate



The Use of Flotation Techniques to Separate Quartz from Feldspar

D. Miallier, S. Sanzelle, and J. Faïn

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We have been successfully using the flotation technique to separate quartz from feldspar prior to TL dating for one year but it became evident at the Helsingør Seminar (July, 1982) that this 25 year old method is still generally unknown in the TL field. Accordingly, we briefly recall here the principle of the very effective Hallimond cell and supply some bibliographic references on flotation.

The technique consists of selectively carrying away certain minerals from a mixed powder with gas bubbles. The buoyancy of a mineral depends on its surface properties and is hardly affected by its density or physical characteristics. The buoyancy of quartz and feldspar is nil but can be enhanced for feldspar with a "collector" so that it can be floated away by bubbles.

The Hallimond cell is composed of two parts (figure 1):

- the lower part (45 cm^3) is fitted with a sintered glass plug and can be placed on a magnetic stirrer.
- the upper part is forked; one branch for filling and the other for recovering the floated minerals.

The two parts are joined by a ground-glass joint.

The cell is used in the following manner:

1. - 0.25 grams of octadecilamine ($CH_3(CH_2)_{17}NH_2$) collector is diluted in 500 cm^3 of water (20°C), a few drops of pine oil or liquid soap added (foam stabilizer-not compulsory) and the pH adjusted to 2-3 with HF (to reduce the buoyancy of the quartz). This is then poured into the cell along with 1-1.5 grams of the powder of quartz and feldspar. The minerals should be cleaned with acids (HF, HCl, etc.) before their introduction so that clean surfaces are exposed to the liquid. Heavy minerals should also be removed (using heavy liquids, for example) if present.
2. - The stirrer is turned on and the gas tap opened.

The efficiency of the cell depends on many factors including grain size, surface state, bubbling rate and pH. Optimally the separation should not take more than 15 minutes. If difficulties are encountered, one of the conditions should be changed and, if necessary, another collector used (e.g., sodium xanthate, potassium ethyl xanthate or sodium oleate). The final, separated powders should be rinsed thoroughly with acetone as the octadecilamine has poor solubility.

We have achieved very good results with the quartzo-feldspathic fraction of granites, with detritic sand and with the xenolithic inclusions of volcanic projections (Miallier, et al., 1982).

* * * * *

We are grateful to Dr. Y. Vialette (Laboratoire de Geochronologie de Clermont-Ferrand) for his help in preparing this paper.

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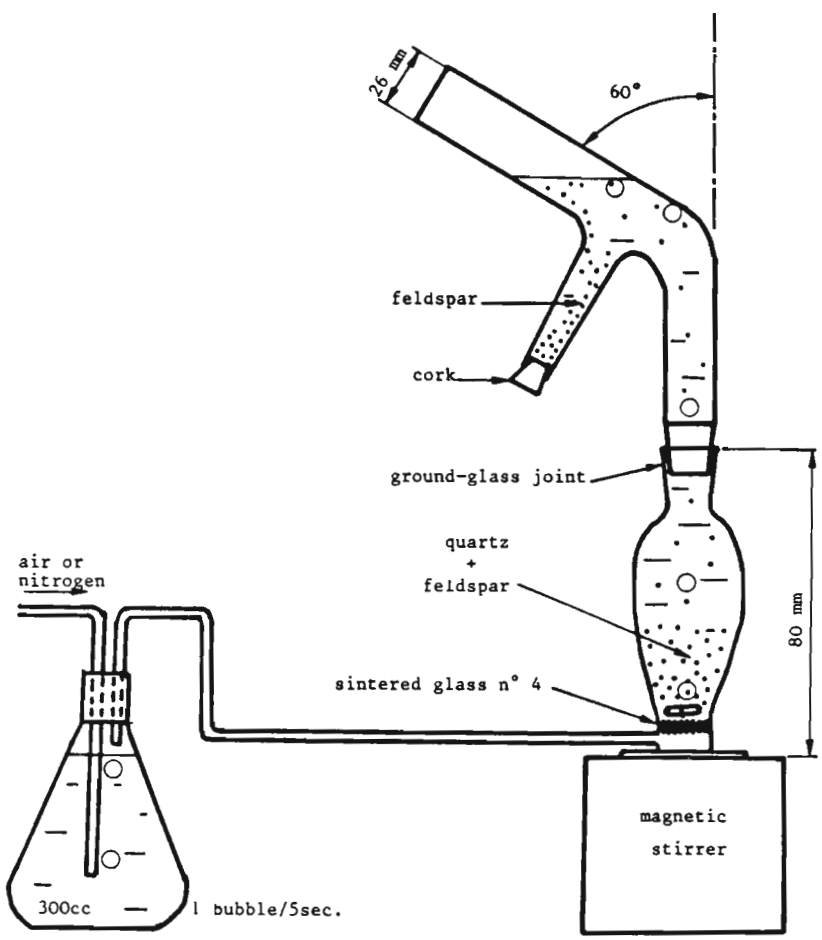
Figure 1: Flotation Apparatus



Universidad Nacional de Ingenieria (Peru) TL Dates-1983 (I)

E. López Carranza[1], S. Benites Legoas[2], A. Valera Palacios[1], H. Barrientos Echegaray[3] and B. Marticorena Castillo[4].

The dates which we report in this paper, the first work of our TL laboratory, were measured in 1979-1980. The "fine-grains" technique of Zimmerman (1971) was utilized. Our TL equipment is from the Littlemore Scientific Engineering Co., Oxford (LSECO), type 711, provided with a photomultiplier tube type EMI 9635QA. Pure argon at a rate of 5 litres/min. was introduced into the evacuated oven for TL measurements. For alpha and beta source calibrations the chamber was filled with a mixture of commercial nitrogen and hydrogen in a proportion of 4/1 after passing a deoxo purifier. The gas pressure inside was maintained at just below atmospheric to keep the oven closed. Beta irradiations were carried out with a Sr-90 source (40 mCi (nominal) SIP 13), calibrated following the method proposed by E. Pernicka and G. A. Wagner (1979). Alpha irradiations were performed with a Cm-242 source (5 mCi), calibrated using essentially the Zimmerman method (1971). Equivalent dose and supralinearity, corrections were obtained by extrapolating first-and second-glow growth curves. Data for the first curve were taken as the average of the measurements on four discs while the second curve points averaged the results of two discs. All TL data was taken at 375°C.

For the sherd coming from the mountain valley the alpha efficiency (a) of 0.15 was determined. For the other sherds, coming from the deserted coast, "a" was assumed to be 0.15 with an overall uncertainty of 20%. The intrinsic radioactivity was determined by measuring the gross alpha particle emission rate (U and Th) with an alpha counter from the LSECO and using flame photometry (K). For the intrinsic dose-rate calculations, the conversion factors of Bell (1976, 1977) were used, for equal activities of uranium and thorium series. Unsealed (α_0) and sealed (α_1) alpha counts were compared. When α_1/α_0 was greater than 1.05 the value $(\alpha_0+\alpha_1)/2$ was used. In other cases α_0 was taken. Saturation water content was assumed for the sherd of the mountain valley and no moisture content was considered for the other sherds. 15 mrad/yr was used as the cosmic radiation dose-rate. For the sherd of the mountain valley, the burial environmental dosage was calculated from radioactive analysis of the soil (stone-free) and taking a saturation water content. 77 mrads/yr was assumed as the environmental dosage for the other sherds. Anomalous fading was not studied in any case. The error assessment system proposed by Aitken and Alldred (1972) and Aitken (1976) was used assuming zero for the uncertainties σ_3 (stone content of soil), σ_7 (radon emanation) and σ_8 (wetness estimate). The dates are in years before A.D. 1980 and the errors appear within parentheses.

Acknowledgements

We acknowledge the Volkswagen Foundation for the donation of our equipment. We thank also the Organization of American States for financial aid to H. Barrientos Echegaray and equipment grants.

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(3) Universidad Nacional San Antonio Abad del Cuzco, Cuzco, Peru.

(4) Universidad Nacional Mayor de San Marcos, Lima, Peru.

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ARCHAEOLOGIC SAMPLES

A. BAYOVAR (Department of Piura, 05°50'S, 81°03'W, in the Sechura desert) Peru.

These sherds were collected by the archaeological group of M. Cárdenas (1979) from the Seminario de Arqueología, Pontificia Universidad Católica del Perú, Lima.

UNI-TL-1 Mochica culture (?) 1020 (±60, ±120), A.D. 960

Pottery: 2.198, P-11. Well A, layer 29, depth 2.70-2.95 m. Sample comes from a sand desert.

Comments- Natural dose: 690 rads (I = 20), δQ = 12%, plateau ≃ 70C. Annual dose: 0.68 rads/yr., α_1/α_0 = 1.0, sherd water ≃ 0, a= 0.15, δa = 20%. ^{14}C date on associated charcoal is 940 ± 110 years (Catholic University, Lima).

UNI-TL-2 Chimú culture (?) 630 (± 40, ± 80), A.D. 1350

Pottery: 2.169, P-7. Well A, layer 3, depth 0.30 m. Sample comes from a sand desert.

Comments- Natural dose: 380 rads (I = 50), δQ = 15%, plateau ≃70C. Annual dose: 0.60 rads/yr, α_1/α_0 = 1.0, sherd water ≃0, a = 0.15, δa = 20%. ^{14}C date on associated charcoal is 630 ± 90 years (Catholic University, Lima).

B. PACHACAMAC (Department of Lima, 12°14'S, 76°52'W, 29 km from Lima) Peru.

The sample was collected by L. Langouet and E. López Carranza. Description of the site is given by Engel (1976).

UNI-TL-3 Inca culture (?) 500 (±30, ±60), A.D. 1480

Pottery: Pach-1, Depth 0.30 m.

Comments- Natural dose: 380 rads (I = 50), δQ = 7%, plateau ≃ 80C. Annual dose: 0.75 rads/yr, α_1/α_0 = 1.0, sherd water ≃0, a = 0.15, δa = 20%.

C. HUARMEY (Department of Ancash, 10°03'S, 78°09'W, on the coast) Peru.

Buried fired stones were collected by D. Bonavia from the Universidad Cayetano Heredia, Lima. Datation of some of these stones are reported by j-F-Rouanet (1976).

UNI-TL-4 Chavín de Huantar (?) 2070 (±120, ±210), 90 B.C.

Fired stone: PV 35-1, B-10. Depth 1.50 m.

Comments- Natural dose: 1370 rads (I = 190), δQ = 5%, Plateau ± 70C. Annual dose: 0.66 rads/yr, α_1/α_0 = 1.0, sherd water ≃ 0, a = 0.15, δa = 20%.

D. MARCAVALLE (Department of Cuzco, 13°31'S, 71°57'W, on a mountain valley) Peru.

The sherd was collected by L. Barreda from the Universidad Nacional San Antonio Abad del Cuzco. Datations on this site are given by K. M. de Chaves (1977).

UNI-TL-5 Chanapata sherd (?) 2380 (±150, ±170), 400 B.C.

Pottery: Marc-1. Depth 1.50 m.

Comments- Natural dose: 840 rads (I = 10), δQ = 9%, plateau ≃ 70C. Annual dose: 0.35 rad/yr using $(\alpha_0+\alpha_1))/2$, α_1/α_0 = 1.07, sherd wt. sat/dry = 1.0, sherd burial water = saturation, a= 0.17, δ = 9%.

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SOME RECENT BIBLIOGRAPHY

M. C. Beltrão, J. Danon, C. R. Enriquez, G. Poupeau and E. Zuleta (1982) Sur l'arrivée de l'Homme en Amérique: datations par thermoluminescence des silex brûlés du site archéologique Alice Boer (Brésil). *C. R. Acad. Sci. Paris, 295*, 629-632.

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Meeting Announcements

7th INTERNATIONAL CONFERENCE ON SOLID STATE DOSIMETRY
Ottawa, Canada - September 27-30, 1983

The seventh in the series of International Conferences on Solid State Dosimetry will be convened in Ottawa, Canada at the Federal Government Conference Centre from September 27 to 30, 1983.

The scientific sessions will cover advances in a variety of fundamental and applied topics concerning solid state dosimeters and dosimetry including

-basic physical mechanisms
-ionizing and UV radiation dosimetry
-exoelectron and track etch techniques
-new materials
-instrumentation
-personnel, environmental and medical dosimetry
-standardization

PROCEEDINGS

The proceedings will be published as a distinctive issue of ***Radiation Protection Dosimetry***, Volume 6. Each participant will receive a copy of the proceedings.

ABSTRACTS

Abstracts should be in English and should give the title, author(s), institution(s), and a summary ***not to exceed 200 words***. Abstracts must be received by the Chairman of the Scientific Advisory Committee on or before January 31, 1983. Acceptance notification will be forwarded by April 30, 1983. A booklet of abstracts will be provided to each participant.

TECHNICAL EXHIBITS

Provision is being made for a limited number of technical exhibits. For details contact Morgan Cox, Harshaw Chemical Company, Crystal and Electronic Products Department, 6801 Cochran Road, Solon, Ohio, 44139 U.S.A.

PROGRAM (ABSTRACTS)

T. Stoebe
University of Washington
Seattle, WA 98195
U.S.A.

LOCAL ARRANGEMENTS

Radiation Protection Bureau
Health and Welfare Canada
Brookfield Road
Ottawa, Ontario, Canada K1A 1C1

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1983 SYMPOSIUM ON ARCHAEOMETRY
Castel Dell'Ovo, Naples, Italy 18-22 April 1983

The 1983 International Symposium is being organised on behalf of the Standing Committee by: R. E. Linington, Fondazione Lerici Prospezioni Archeologiche, Via V. Veneto 108, 00187 Rome, Italy (tel.01/460083), with contributions from the Fondazione Lerici, the Italian Ministero dei Beni Culturali e Ambientali and from UNESCO.

TOPICS and CONVENORS:

Theme Session:

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and

A. Hesse, Centre de Recherches Géophysiques Garchy, 58150 Pouilly sur Loire, France.

Provenance Studies:

G. Harbottle and E. Sayer, Dept. of Chemistry, Building 555, Brookhaven National Laboratory, Upton, NY 11973, U.S.A.

Ancient Metals and Metallurgy:

R. Maddin, University of Pennsylvania, Philadelphia, PA 19104, U.S.A.

Ancient Technology: non-metals:

M. S. Tite, The British Museum, Research Laboratory, London WC1B 3DG, U.K.

Dating of organic materials (e.g. radiocarbon and other cosmogenic nuclides, dendrochronology, amino acid dating):

E. T. Hall, Research Laboratory for Archaeology, 6 Keble Road, Oxford OX1 3QJ, U.K.

Dating of inorganic materials (e.g. thermoluminescence, ESR, fission tracks, uranium-series, archaeomagnetism):

M. J. Aitken, Research Laboratory for Archaeology, 6 Keble Road, Oxford OX1 3QJ, U.K.
and

L. Langouet, Université de Rennes, Campus de Beaulieu, Avenue de General Leclerc, 35031 Rennes Cedex, B.P. 25A, France.

Mathematical methods and date management:

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