Pergamon

Radiation Measurements, Vol. 25, Nos 1–4, pp. 459–460, 1995

1350-4487/95 $9.50 + .00

1350-4487(95)00162-X

PROBLEMS RELATED TO THE EMPLOYMENT OF THIN URANIUM FILMS AS NEUTRON DOSIMETERS

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ABSTRACT

Thin uranium films built on muscovite mica basis and obsidian samples having known ages were irradiated with thermal neutrons at the IPEN/CNEN reactor, São Paulo. Comparing thin film performance with the obsidian one, it was observed that the latter "feel" a greater neutron fluence. Nominal fluences at the used facility are in agreement with the results obtained analysing the obsidian samples. A probable hypothesis to explain this disagreement, namely, the uranium loss from the thin films, was ruled out.

KEYWORDS

Fission track dating; neutron dosimetry; uranium thin films

INTRODUCTION

Thin films of uranium can be used in order to obtain thermal neutron fluences (see, for instance, Wall, 1986). They are specially suitable in the so-called neutron dosimetry of the Fission Track Method (Bigazzi *et al.*, 1993). This occurs because both the "neutron dosimeter" and the mineral are based on the same nuclear reaction, U-235(n,f) (see, for instance, Green and Hurford, 1984). In a previous work, we had noted that the response of thin films is different from the mineral one, when they are submitted to the same neutron irradiation (Hadler *et al.*, 1993). Up to now, our results have indicated that films with an uranium content lower than approximately 10^{14} atoms/cm^2 loose uranium due to the manipulation. In this work, this problem is analysed by calibrating the films, using their own α-activity, before and after the irradiation, and having obsidians with known ages were also present.

EXPERIMENTAL PROCEDURE

The obsidian samples employed in this work were the Mullumica (abrigo 2), Callejones (sample 3) from Ecuador and Monte Arci (n°6) from Italy. Each sample was separated in two parts. The first one was used in order to obtain the fossil track density. The second one was sandwiched between two natural uranium thin films. This assembly was irradiated at the IPEN/CNEN reactor in São Paulo, with a nominal thermal neutron fluence of 1.46 x 10^{15} cm^{-2}. The cadmium ratio in the irradiation position (14b, rack 5) was approximately 50 for obsidian. In this way, the U-235 fissions by fast and epithermal neutrons, and the U-238 and Th-232 ones by fast neutrons, were neglected. By using the age equation (Price and Walker, 1963), the thermal neutron fluence, ϕ, "felt" by the obsidian, can be obtained, if we consider only the U-235 fissions by thermal neutrons. In the case of the uranium thin films, the thermal neutron fluence can be obtained by measuring the superficial track density of induced fission, ρ_F, in a muscovite mica with a low uranium content, which was coupled to it during the irradiation. To accomplish this, it is necessary to know the number of uranium atoms per unit area in the film, N (Bigazzi *et al.*, 1993) and the detection efficiency of the muscovite mica (Bigazzi *et al.*, 1991).

RESULTS AND DISCUSSION

The employed films (A and G) were calibrated before (first exposition) and after (second exposition) the irradiation. The corresponding values of N are shown in Table I. In this irradiation (I05/93-17), ϕ was obtained by using the mean value of N. The values of ρ_F and ϕ, corresponding to the employed films, are also shown in this Table. Table II shows the values of T, ρ_S , ρ_I and ϕ corresponding to the obsidians employed in this work. The apparent ages of the obsidians were taken from Bigazzi *et al.* (1992) (mullumica (abrigo 2) e callejones (sample 5)) and from Arias *et al.* (1986) (Monte Arci, No.6). The value of the decay constant of the U-238 spontaneous fission, which was used to obtain ϕ , was $(7.03 \pm 0.11) \times 10^{-17}\ y^{-1}$ (Roberts *et al.*, 1968). The values of the α-decay constants, the isotopic concentrations and the cross section of U-235 for thermal neutron fission, which were employed in the determination of N and ϕ , were obtained from Lederer and Shirley (1978).

By comparing the results contained in Tables I and II, it can be seen that the fluences that the obsidians "felt" are higher than the ones "felt" by the films. As the thin films were calibrated before and after the irradiation, the uranium loss from the films was unconsidered as the cause of the different response between obsidians and films. Table II also shows that the fluence corresponding to the sample from Mullumica was different from the Monte Arci's one. Nowadays, we are working with the hypothesis that the packets containing the thin films can be causing a depression on the thermal neutron flux.

Table I: Determination of the fluence using thin films

Film	N (first exposition) (10^{13} cm^{-2})	N (second exposition) (10^{13} cm^{-2})	ρ_F (10^5 cm^{-2})	ϕ (10^{15} cm^{-2})
A	5.5 ± 0.4	5.7 ± 0.5	2.4 ± 0.1	1.0 ± 0.1
G	15 ± 1	13 ± 1	5.3 ± 0.2	0.9 ± 0.1

Table II: Determination of the fluence using obsidians with known ages

Obsidian	T (10^5 y)	ρ_S (10^2 cm^{-2})	ρ_I ($10^5 cm^{-2}$)	ϕ (10^{15} cm^{-2})
Mullumica (abrigo 2)	1.6 ± 0.1	4.0 ± 0.3	1.7 ± 0.1	1.2 ± 0.1
Callejones (sample 3)	1.7 ± 0.1	3.4 ± 0.3	1.8 ± 0.1	1.5 ± 0.2
Monte Arci (No. 6)	27 ± 2	49 ± 3	18 ± 1	1.6 ± 0.1

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