Alpha radiation doses to the eyes of individuals wearing optical glasses

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Abstract

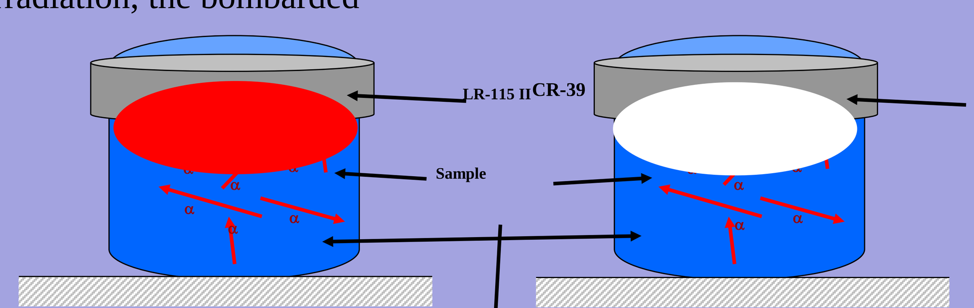
Optical glasses are presently utilized by a great number of individuals to correct vision weakness. Two types of solid state nuclear track detectors were used for measuring uranium (^{238}U), thorium (^{232}Th), radon (^{222}Rn) and thoron (^{220}Rn) contents in various optical glasses as well as radon and thoron in air. Radiation doses to eyes of individuals due to alpha-particles emitted by the ^{238}U and ^{232}Th series inside the studied optical glasses and those emitted by the radon and thoron series in air were evaluated. The influence of the nature of the optical glasses as well as radon concentration in air on radiation doses received by individuals wearing optical glasses was studied. Radiation doses were found higher for persons wearing mineral optical glasses than for those wearing organic optical glasses.

Introduction

Uranium and thorium contents have been betermined in different geological materials by using chemical or instrumental methods. These techniques are expensive and need standards for their calibration. In a previous article we developed an experimental method for determining uranium and thorium contents in different geological samples by using solid state nuclear track detectors (SSNTD). In this work, we describe a new calculation method, adapted to the experimental conditions, for determining directly thorium and uranium contents in different optical glass samples. We also estimed alpha doses received by individuals wearing optical glasses. The necessary ranges of α-particles emitted by the uranium and thorium series, in the considered materials were calculated by means of a TRIM programme.

Methodology

Disk shaped CR-39 and LR-115 type II SSNTD have been separately placed on an optical glass sample in a closed cylindric plastic container of 4 cm diameter and 1 cm depth for one month (Fig. 1). During this time α-particles emitted by the and thorium (^{232}Th), uranium (^{238}U) and their daughters bombarded the SSNTD films. After the irradiation, the bombarded



Plastic container

SSNTD were developed in a NaOH solution (2.5M at 60 °C during 120 minutes for LR-115 films and 6,25M at 70 °C during 7 hours for the CR-39 ones)[1]. After this chemical treatment the CR-39 and LR-115 α-particle track densities were determined by means of an ordinary microscope.

The global density of tracks due to the α-particles of the uranium and thorium series, registered on the CR-39 and LR-115 type II SSNTD are giver by:

$$\rho_G^{CR} = C(U)d_s\left[A_U(Bq/g)\sum_{j=1}^{8}K_jP_j^{CR}R_j + A_{Th}(Bq/g)\frac{C(Th)}{C(U)}\sum_{j=1}^{7}K_jP_j^{CR}R_j\right] \quad (1)$$

$$\rho_G^{LR} = C(U)d_s\left[A_U(Bq/g)8P^{LR}\Delta R + A_{Th}(Bq/g)6P^{LR}\Delta R\frac{C(Th)}{C(U)}\right] \quad (2)$$

Combining Eqs (1) and (2), we obtain the following relationship between track densities And thorium to uranium ratios

$$\frac{\rho_G^{CR}}{\rho_G^{LR}} = \frac{A_U(Bq/g)\sum_{j=1}^{8}K_jP_j^{CR}R_j + A_{Th}(Bq/g)\frac{C(Th)}{C(U)}\sum_{j=1}^{7}K_jP_j^{CR}R_j}{8A_U(Bq/g)P^{LR}\Delta R + 6A_{Th}(Bq/g)P^{LR}\Delta R\frac{C(Th)}{C(U)}} \quad (3)$$

Knowing ρ_G^{CR}, ρ_G^{LR} , P_j^{CR} and P^{LR} one an determine the $\frac{C(Th)}{C(U)}$ ratio and consequently the thorium $C(Th)$ and uranium $C(U)$ contents in an optical glass sample.

Committed effective doses (Sv y^{-1} cm^{-2}) to eye due to ^{238}U, ^{232}Th and ^{222}Rn from wearing optical glasses by individuals are respectively given by (Misdaq and Outeqablit 2010):

$$E_U = \frac{kK_US_UW_R}{2d_{skin}S_{skin}\lambda_U}\times A_c^{sample}(^{238}U)(1-e^{-\lambda_Ut_e})w_T \quad (4)$$

$$E_{Th} = \frac{kK_{Th}S_{Th}W_R}{2d_{skin}S_{skin}\lambda_{Th}}\times A_c^{sample}(^{232}Th)(1-e^{-\lambda_{Th}t_e})w_T \quad (5)$$

$$E_{Rn} = \frac{kK_{Rn}S_{Rn}W_R}{2d_{skin}S_{skin}\lambda_{Rn}}\times A_c^{sample}(^{222}Rn)(1-e^{-\lambda_{Rn}t_e})w_T \quad (6)$$

Where $A_C^{sample}(^{238}U)$ is the alpha activity due to ^{238}U nside an optical glass sample. $A_C^{sample}(^{232}Th)$ is the alpha activity due to ^{232}Th inside an optical glass sample. $A_C^{sample}(^{222}Rn)$ is the alpha activity due to ^{220}Rn inside an optical glass sample. λ_U is the radioactive decay constant for ^{238}U. λ_{Th} is the radioactive decay constant for ^{232}Th . λ_{Rn} is the radioactive decay constant for ^{222}Rn. t_e is the exposure time. $W_T = 0.01$ is the tissue weighting factor for ski (ICRP 2002) [2]. K_U is the branching ratio for disintegration. is the branching ratio for ^{238}U disintegration. K_{Th} is the branching ratio for ^{232}Th disintegration. K_{Rn} is the branching ratio for ^{222}Rn disintegration d_{skin} is the density of skin (g cm^{-3}). S_{skin} is the surface eye (cm^2) (ICRP 1990)[3]. K=1.6 10^{-13} (J MeV^{-1}) is a conversion factor. S_U is the stopping power of skin for the alpha particles emitted by ^{232}Th (MeV cm^2 g^{-1}). is the stopping power of eye for the alpha particles emitted by (MeV cm^2 g^{-1}).S_{Rn} is the stopping power of eye for the alpha particles emitted by ^{222}Rn (MeV cm^2 g^{-1}).

Results

Different optical glass samples have been collected and their uranium, thorium, and radon concentrations have been determined. Data obtained are shown in Table1. The relative uncertainty on the uranium, thorium, and radon concentration determination is of 8%.

Optical glass sample	$A_c(^{238}U)$ (mBq/kg)	$A_c(^{232}Th)$ (mBq/kg)	$A_c(^{222}Rn)$ (Bq/kg)	$A_c(^{220}Rn)$ (Bq/kg)
OG1	3,32±0,25	0,57±0,04	3,32±0,25	0,57±0,04
OG2	6,89±0,37	1,11±0,08	6,89±0,37	1,11±0,08
OG3	18,20±0,98	3,03±0,16	18,20±0,98	3,03±0,16
OG4	16,60±0,98	3,53±0,20	16,60±0,98	3,53±0,20
OG5	11,44±0,49	2,25±0,12	11,44±0,49	2,25±0,12
OG6	10,45±0,74	1,64±0,08	10,45±0,74	1,64±0,08
OG7	26,57±1,23	4,71±0,20	26,57±1,23	4,71±0,20
OG8	10,45±0,49	1,85±0,08	10,45±0,49	1,85±0,08
OG9	8,86±0,37	1,64±0,08	8,86±0,37	1,64±0,08
OG10	7,99±0,61	1,23±0,08	7,99±0,61	1,23±0,08
OG11	11,19±0,61	2,13±0,12	11,19±0,61	2,13±0,12
OG12	9,59±0,61	1,56±0,04	9,59±0,61	1,56±0,04

Committed effective doses to the eyes of individualswearing the studiedoptical glass samples due to 238U, 232Th and 222Rn have been evaluated. Data obtained are shown in Table 2.Radiation doses were found higher for persons wearing mineral optical glasses than for those wearing organic optical glasses.

Optical glass sample	Adult (Male)			Adult (Female)		
	E_U ($10^{-6}Sv.y^{-1}.cm^{-2}$)	E_{Th} ($10^{-6}Sv.y^{-1}.cm^{-2}$)	E_{Rn} ($10^{-6}Sv.y^{-1}.cm^{-2}$)	E_U ($10^{-6}Sv.y^{-1}.cm^{-2}$)	E_{Th} ($10^{-6}Sv.y^{-1}.cm^{-2}$)	E_{Rn} ($10^{-6}Sv.y^{-1}.cm^{-2}$)
OG1	51±3	1.00±0.06	4.1±0.2	59±3	1.15±0.07	4.7±0.3
OG2	64±4	0.94±0.06	5.2±0.3	73±5	1.08±0.07	5.9±0.4
OG3	99±7	2.0±0.1	8.0±0.5	113±8	2.3±0.1	9.1±0.7
OG4	34±2	0.84±0.06	2.7±0.28	39±2	0.96±0.06	3.1±0.2
OG5	1.9±0.1	1.6±0.1	0.15±0.01	2.2±0.1	1.8±0.1	0.17±0.01
OG6	3.9±0.3	2.2±0.1	0.31±0.02	4.4±0.3	2.5±0.1	0.36±0.03
OG7	10.9±0.7	7.0±0.4	0.88±0.06	12.5±0.8	8.0±0.5	1.00±0.06

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