THERMOLUMINESCENCE STUDY OF NATURAL QUARTZ INCLUSIONS IN SILICATE BRICKS FOR DOSE RECONSTRUCTION IN AREAS DOWNWIND OF CHERNOBYL

V.B. MIKHAILIK, I.K. BAILIFF

Luminescence Dosimetry Laboratory, Environmental Research Centre, University of Durham
(South Road, Durham DH1 3LE, United Kingdom; e-mail: vmikhai@hotmail.com)

UDC 532

The potential of calcium silicate brick (CSB) — a construction material widely used in the contaminated settlements downwind of Chernobyl — for its use in retrospective dosimetry has been investigated. The procedure of dose evaluation taking advantage of the 210 °C thermoluminescence (TL) peak of quartz inclusions was examined using CSB samples subjected to the natural or laboratory irradiation. The CSB manufacturing procedure that includes the stage of long-term firing at a temperature of about 200 °C has been shown to facilitate the eviction of charge carriers from the traps associated with the 210 °C TL peak, providing thereby the necessary zeroing of the geological TL signal. The TL sensitivity of quartz has been demonstrated to be sufficient to measure absorbed doses of about 10 mGy and above. When applied to the field specimens from a contaminated settlement, the estimate of the cumulative fallout dose was in a good agreement with the result obtained in the previous study of ceramic (fired) bricks from the same building.

1. Introduction

Since the opportunities of luminescence for finding the dose of radiation absorbed by natural materials had been demonstrated for the first time [1], the corresponding technique has become an integral component of retrospective dosimetry. It is widely used in the researches aimed at the reconstruction of the radiation situation in the areas subjected to the radiation contamination under accidental conditions [2, 3]. The luminescence methods of dosimetry are based on measuring a luminescence signal that emerges owing to the thermally or optically stimulated escape of charge carriers from traps, where they have been captured under the action of ionizing radiation [4]. Owing to the natural radiation background, the principal methodological difficulty for the retrospective dosimetry that uses conventional natural materials is the finding of the correct "reference point" — the initial level of the trap population which preceded the accidental irradiation. Nowadays, any practical application of luminescence methods in the retrospective dosimetry is based on the assumption that such traps become thermally or optically depleted either in the course of material fabrication or being subjected to the long-term action of sunlight; this process is also known as crystal bleaching. The methods developed are based on the measurement of thermoluminescence (TL) or optically stimulated luminescence (OSL) of natural quartz and possess a rather high sensitivity allowing an absorbed accidental dose of about 20 mGy to be detected in fired bricks and other ceramic materials [5]. However, such materials are not always available in the settlements of the areas downwind of Chernobyl. Therefore, the studies of non-ceramic constructional materials, which would allow the scope of application and the capabilities of luminescence methods in retrospective dosimetry to be expanded considerably, have drawn interest recently.

One of such materials is silicate brick, which has been widely used by the building industry since the early 1970s as a cheaper alternative to fired-brick. For this reason, the majority of constructions in the areas that have suffered from the Chernobyl accident had been built out of this material. Earlier, silicate bricks that have not been fired at high temperatures in the course of their fabrication were considered unsuitable for the determination of the accidental dose, since the luminescence signal would be caused by that radiation dose, which the material (quartz) has absorbed for the period of its geological history (the so-called geological dose). Recently, however, we have noticed an interesting fact; namely, the fabrication technology of silicate bricks includes the stage of their long-term exposure at raised pressure and temperature (autoclaving) [6], which can be of principal importance for the problem concerned. On this basis, the assumption has been put forward that such a low-temperature (about 200 °C) but long-term (8—12 h) stage of the treatment could be sufficient for the thermally induced depopulation of traps and erasing the geological TL signal in the vicinity of 200 °C. It would allow in turn the geological and accidental doses to be distinguished by applying the TL method of research. Taking into account the importance of determination of the value of the acquired accidental dose for estimating both the radiation risk and the relevant consequences for human health, for carrying out the radio-epidemiological studies and making a decision concerning the necessity of the resettlement of the radiation-contaminated areas, the development of new techniques of retrospective researches is challenging. All the mentioned above stimulated us to initiate the studies of whether silicate brick can be used for the retrospective dosimetry of settlements.

2. Measurement Procedure

In this work, we studied three types of specimens: the fragment of a silicate brick from a 21-year-old building in the village of Narodychi (Zhytomyr region, Ukraine) subjected to the radioactive contamination because of the Chernobyl accident in 1986 (C-1); the fragment of a 20-year-old brick taken at the town of Pustomyty (Lviv region, Ukraine) (C-2); and the fragment of a modern silicate brick fabricated in the United Kingdom (C-3). As follows from the description above, since the time of its fabrication, specimen C-1 has been exposed to both the natural and accidental radioactivity. The cumulative dose induced by the accidental irradiation has been measured earlier making use of a fire-brick taken from the same building [7]. At the same time, samples C-2 and C-3 have been irradiated in the natural way only.

With the purpose to study the validity of using silicate bricks in retrospective dosimetry, we simulated the effect of accidental radioactive irradiation. A block 10 mm in thickness was cut from each brick fragment. Then, these blocks were irradiated up to a dose of 500 mGy, making use of a gamma-ray source ^{137}Cs. The list of specimens, their treatments before exposition, and the components of the absorbed radiation dose are quoted in Table 1.

Quartz inclusions for research purposes was extracted from the silicate brick samples following the technique developed for ceramic materials containing quartz [8]. The procedure includes the stages of mechanical crushing, sieving, and etching in hydrofluoric acid for the careful purification of the end-product. The 2—3-mg aliquots of quartz sand, deposited onto an 8-mm stainless steel disk, served as a separate specimen for measurements. In order to obtain the necessary statistics, at least 6 such aliquots were measured in the course of each experiment.

The measurements were carried on using a Risø TLDA-12 device for TL studies, equipped with an EMI-9235QB photodetector operating in the photon-counting mode. In this device, the laboratory dose of ionizing radiation was delivered from a standardized ^{90}Sr/^{90}Y beta-emitting source (550 mGy/min). The TL glow curves were recorded to the maximal temperatures $T_{\max} = 250$, 270, and 300 °C at a rate of 2 °C/s. The composition of the annual components of natural radioactivity was determined using the beta TL-dosimetry and alpha-particle-counting methods [8]. In addition, the concentrations of radioactive isotopes ^{238}U, ^{232}Th, and ^{39}K were found from mass-spectroscopy measurements; the results obtained served as the basis for the calculation of the annual natural radiation background for each silicate brick sample.

Table 1. Results of measurements of the doses D_T absorbed by silicate brick specimens

N	Specimen	Treatment	Components of D_T	D_T, mGy		
				T_m=250 °C	T_m=270 °C	T_m=300 °C
1	C-1A	γ	$D_R+D_{\rm BG}+D_X+D\gamma$	533±12	542±9	557±6
2	C-2A	γ	$D_R+D_{\rm BG}+D\gamma$	533±19	676±12	—
3	C-3A	γ	$D_R+D\gamma$	485±21	500±26	547±17
4	C-1Б	12h at 200 °C+γ	$D_R+D\gamma$	488±12	487±11	505±6
5	C-2Б	12h at 200 °C+γ	$D_R+D\gamma$	456±11	495±26	574±20
6	C-1B	12h at 200 °C	D_R	<10	<10	<10
7	C-2B	12h at 200 °C	D_R	14±13	19±13	21±11
8	C-1Г	no	$D_R+D_{\rm BG}+D_X$	25±5	32±4	35±3
9	C-2Г	no	$D_R+D_{\rm BG}$	141±6	135±15	148±16
10	C-3Г	no	D_R	26±6	25±6	70±9

Notes: γ means the laboratory irradiation to a dose of 500 mGy

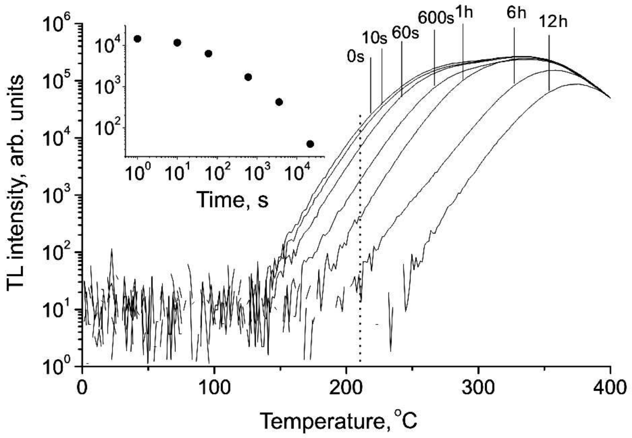

Fig. 1. Shapes of the TL glow curves of natural quartz depending on the exposure time at a temperature of 200 °C. The inset shows the variation of the TL intensity in the vicinity of 210 °C

3. Results

3.1. *Influence of temperature and time on the 210 °C TL band of natural quartz: test for the "crystal-bleaching" feasibility*

As a starting point of this research, we used the fact that the TL band located in the vicinity of 210 °C, which is characteristic of natural quartz obtained from ceramic materials, is widely used for reconstructing the absorbed dose [4, 9, 10] and dating the archeological objects younger than 1000 years [11].

The main idea of the method consists in the assumption that the traps, which are responsible for TL in the vicinity of 200 °C, can be depopulated. Therefore, we have studied, first of all, how a long-term exposure of silicate bricks at the characteristic temperature of the technological process of their fabrication (about 200 °C) influences the intensity of the 210 °C TL band.

A sample of natural quartz with a geological dose of irradiation that exceeded 100 mGy was used in experiment. To simulate the effect of thermally stimulated "bleaching", which occurs during the manufacture of silicate bricks, the sample had been kept at a temperature of 200 °C for various time intervals (up to 12 h); afterwards, TL measurements were carried out. Fig. 1 demonstrates the change of the TL glow curves depending on the duration of such a heat-treatment procedure; the inset displays the reduction with time of the TL signal intensity in the vicinity of the 210 °C band. It is evident that the intensity of the TL signal in the vicinity of the 210 °C band fades by three orders of magnitude after the thermal treatment during 6 h and becomes practically equal to the background level. This means that, in fact, the traps that are responsible for this TL band are depopulated.

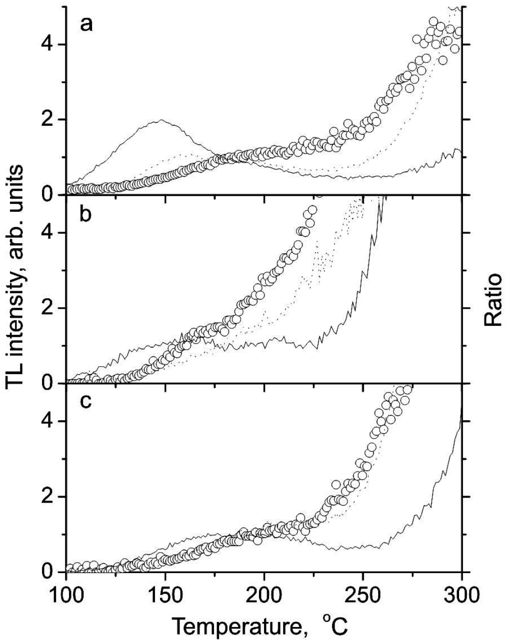

Fig. 2. "Plateau" test for specimens C-1 (*a*), C-2 (*b*), and C-3 (*c*). The TL glow curves were measured for specimens irradiated with an experimental gamma- (solid) and a laboratory beta-dose (dashed curve). The ratio between these curves are shown by points

The basic conclusion, which can be drawn from this experiment, is as follows: if quartz has been kept at a temperature of 200 °C for longer than 6 h (which is typical of the technological process of fabrication of silicate bricks), the 210 °C TL band becomes very weak or disappears owing to the thermally stimulated depopulation of traps. The latter circumstance gives a ground for a more careful study of opportunities which the use of silicate bricks in retrospective dosimetry can provide.

3.2. *TL features of quartz extracted from silicate bricks from the viewpoint of radiation measurements*

The next step of our researches comprised the study of the practical aspects of the problem; in particular, these included the development of the TL-measurement

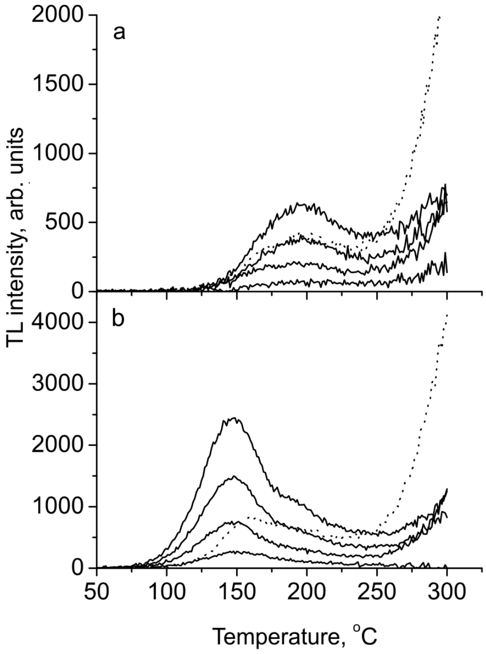

Fig. 3. TL glow curves of specimen C-1A preliminary heated up to various temperatures: 160 (*a*) and 120 °C (*b*). The specimens were exposed to the laboratory beta-irradiation up to doses of 91, 273, 546, and 910 mGy (from bottom to top)

methodology intended for the study of quartz extracted from silicate bricks and determining the dose absorbed.

Fig. 2 shows the TL glow curves of samples C-1, C-2, and C-3, each irradiated with an experimental dose of 500 mGy from the gamma-ray source, and the analogous curves obtained after the same specimens were irradiated by the laboratory beta-source in the course of the experiment aimed at the determination of the absorbed dose. In addition, this figure shows the ratio between the corresponding values of those two curves; this quantity is a parameter, which represents the so-called test for the availability of a "plateau", i.e. the temperature range suitable for radiation measurements, because here the TL signal is proportional to the absorbed dose [8]. One can see from Fig. 2 that the temperature dependence of this parameter differs for different specimens of silicate brick. In the case of specimen C-1, three temperature ranges can be distinguished. Below 180 and above 230°C, the ratio between the TL glow curves varies very sharply, whereas this parameter varies moderately (±10%) within the indicated temperature interval and, moreover, completely overlaps the 210 °C TL band of natural quartz which is used in retrospective dosimetry. Less favorable is the situation for specimen C-3, for which the plateau covers the temperature range from 190 to 210 °C. Some confinement of this temperature interval affects the measurement accuracy; however, in general, the specimens of such a type can be used for the determination of the absorbed dose. At last, in the case of specimen C-2, the ratio between the TL glow curves shows no plateau; this testifies that, owing to certain circumstances occurring during the silicate brick fabrication, the traps connected with the TL band in the vicinity of 210 °C were not depleted completely. Therefore, such a specimen would be of little use for radiation monitoring.

In the course of the experiment devoted to the determination of the absorbed radiation dose in natural quartz, when specimens were irradiated up to the laboratory dose and their TL was measured, it was important to avoid the contributions of low-temperature bands located within the range of 100—180 °C, because those bands can overlap with the 210 °C TL band and deteriorate the accuracy of the measurements. The best result was attained, when the specimen had been preliminarily heated up to temperatures of 120—180°C. As a result, the TL signal from low-temperature peaks became "erased", and the following TL measurement gave only the signal produced by the bands in the vicinity of 210 °C and above [4, 11]. The researches revealed that the shape of the TL glow curves after the specimens having been irradiated with the laboratory dose correlates better with that demonstrated by experimental (irradiated by the gamma-ray source) specimens, if the latter had been preliminarily heated up to a temperature of 160 °C and at a rate of 2 °C/s (see Fig. 3). For this reason, such a routine, which allowed the '210°C' TL band to be singled out precisely, was used in the following measurements.

3.3. Determination of the dose absorbed by silicate brick

In order to measure the dose absorbed by silicate brick, the single-aliquot method, which has been developed for quartz extracted from the ceramic (fired) products [4, 10], was used. The samples to be measured were subjected to various treatments. These included

a) irradiation with a dose of 500 mGy from a gamma-ray source;

b) exposure at a temperature of 200 °C during 12 h, followed by irradiation as in case A;

c) exposure at a temperature of 200 °C during 12 h;

d) no additional treatment.

Numerous measurements carried out for specimens of each type showed that the TL spectra of natural quartz are rather sensitive to ionizing radiation. Moreover, the linear dependences of the TL signal on the absorbed dose within the interval 0.1—10 Gy was obtained for the majority of aliquots.

Adopting the technique proposed in work [2] as the basis, the accidental dose D_X absorbed from artificial sources of gamma-radiation, such as, e.g., the fallout, can be determined for ceramic materials of the known age A as the difference between the total dose D_T absorbed by a specific specimen and the dose D_{BG} caused by the natural radioactive background:

$$D_X = D_T - D_{\mathrm{BG}}. \tag{1}$$

The quantity D_{BG} can be found using the technique developed for quartz inclusions in ceramics, namely,

$$D_{\mathrm{BG}} = A(\check{D}_\alpha + \check{D}_\beta + \check{D}_\gamma + \check{D}_c). \tag{2}$$

In expression (2), the quantities $\check{D}_\alpha$, $\check{D}_\beta$, and $\check{D}_\gamma$ are the annual radiation doses from natural sources of alpha-, beta-, and gamma-radiation, respectively; and $\check{D}_c$ is the annual radiation dose from cosmic rays. The contribution of each component can be estimated using various methods of dosimetry; it can also be calculated, if the concentrations of radioactive elements are known [8, 11]. However, in the case of silicate brick, a probable residual TL signal, which may give an additional contribution to the total experimentally measured value of D_T in the form of the residual dose D_R, has to be taken into consideration. In view of this circumstance, the accidental absorbed dose should be determined using the following expression:

$$D_X = D_T - (D_{\mathrm{BG}} + D_R). \tag{3}$$

Therefore, another important task of this work consists in establishing both the amplitude of this effect for specimens of various types and the optimal conditions for reducing its influence on the accuracy of determination of the accidental dose.

The values obtained for the absorbed dose D_T are quoted in Table 1. The results concerning the estimation of the natural radioactive background in the silicate brick specimens that were used in this research are listed in Table 2. We note that the routine used for the preparation of specimens, which includes etching, enabled us to ignore the contribution of alpha radiation; the annual dose of cosmic radiation amounts to 0.15 mGy.

The most important result which follows immediately from the analysis of the data in Table 1 is the fact that the amplitude of the absorbed dose D_T determined for the silicate brick specimens irradiated by the gamma-ray source (types A and B) agrees reasonably well with the experimental dose $D_\gamma = 500$ mGy. The magnitude of D_T was always smaller for those specimens which had been additionally kept at a temperature of 200 °C before irradiation (type B). Such a result completely agrees with our expectations, because the value of D_T obtained for the irradiated specimens without thermal treatment (type A) includes the contribution from at least one more component, D_{BG} (and the component D_X as well, in the case of specimens C-1A).

As was indicated above, the characteristic feature of quartz, which was extracted from a silicate brick and was the object of this research, is the presence of deep traps occupied by charge carriers. This circumstance inevitably leads to the emergence of a powerful signal in the high-temperature portion of the TL glow curves (roughly speaking, in the vicinity of 300 °C). To elucidate how this signal can affect the result of the absorbed dose determination, the TL glow curves were measured up to temperatures of 250, 270, and 300 °C.

It is worth noting the fact that the obtained value of D_T increases as the maximal temperature, at which TL was measured, grows. This effect is evident for specimens C-2 and C-3, being considerably less pronounced for specimen C-1. This demonstration is consistent with the presence of deep traps occupied by charge carriers, which contribute to the TL signal at high

Table 2. Concentrations of natural radioactive nuclides and the components D_β and D_γ of the annual natural radioactive background obtained for silicate brick specimens

N	Specimen	Age (year)	${D_\beta}^a$ (mGy/year)	U (ppm)	Th (ppm)	K (ppm)	${D_\beta}^b$ (mGy/year)	${D_\gamma}^b$ (mGy/year)
1	CSB-1	21	0.23±2	0.49±.01	0.70±.01	1300±90	0.21±1	0.11±1
2	CSB-2	20	0.11±2	0.99±.01	0.63±.01	1340±100	0.29±1	0.14±1
3	CSB-3	<1	1.01±2	0.71±.01	2.53±.01	11025±500	1.24±1	0.49±1

Notes: *a* determined by the method of TL-dosimetry, *b* calculated on the basis of concentrations using the technique reported in work [8].

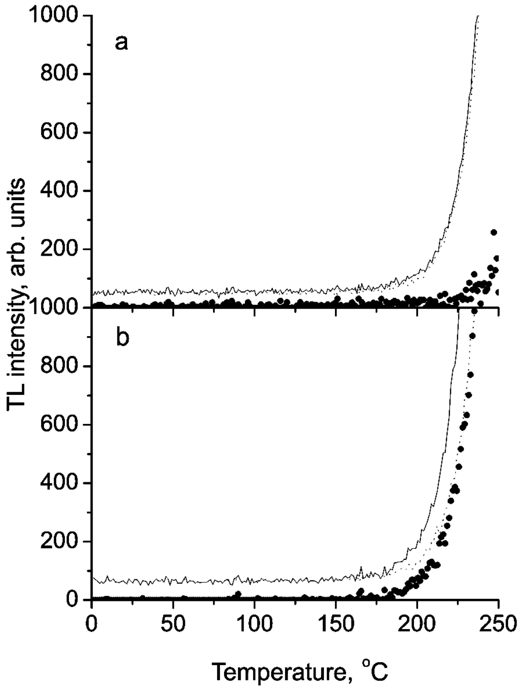

Fig. 4. TL spectra registered for specimen C-2D while measuring up to 250 (*a*) and 300 °C (*b*): the TL signal (solid), the background signal (dashed curve), and their difference (points), i.e. the TL glow curve

temperatures independently of the absorbed dose. The manifestation of this effect can be better understood, having analyzed the experimental data of TL measurements for the untreated specimen C-2D (see Fig. 4).

As is known, the TL glow curve is calculated as a difference between two experimental curves — the first represents the total TL signal from a specimen, and the second is the background component only. In Fig. 4, all the three curves are depicted: the TL signal by the solid curve, the background component by the dashed one, and their difference — in fact, the TL glow curve itself — by points. If the maximal temperature of the TL experiment is low, the deep traps are affected weakly, and the TL signal associated with the geological dose does not manifest itself (Fig. 4,*a*). But if the maximal temperature is high enough — in this case, 300 °C — a certain fraction of deep traps becomes depopulated in the course of the registration of the total TL signal, so that the intensity of the background TL signal in the high-temperature range becomes considerably lower. As a result, the difference curve grows abruptly (see Fig. 4,*b*). It is quite evident that this effect has to be more pronounced for the specimens with incomplete thermal "bleaching", which is in full agreement with the results obtained. A pragmatic conclusion, which follows from this observation, is that a too high or too low maximal temperature of the TL experiment can bring about either over- or underestimation of the absorbed dose, respectively. Therefore, this experimental parameter has to be selected carefully, in order to reduce the measurement errors. In our case, the optimal temperature of 270 °C was found.

Let us analyze the obtained results in more details, by applying the procedure of reconstruction of the absorbed dose which is represented by formulas (1)—(3). The magnitudes of the natural dose of 11 ± 2 and 10 ± 2 mGy acquired by specimens C-1 and C-2, respectively, were estimated using the data on the concentrations of natural radioactive nuclides and the known ages of the specimens. Since specimen C-3 has been fabricated only a few months before measurements, its natural dose can be neglected.

According to expression (3), the main error on the determination of the accidental dose D_X absorbed by silicate brick is induced by the residual dose D_R. In the case of specimen C-3, the numerical value of the quantity D_T, which was found for the untreated specimen, corresponds to the residual dose D_R, because the component D_{BG} for an as-fabricated specimen can be neglected. The results quoted in Table 1 testify that the value of D_R for specimen C-3 is equal to about 25 mGy ($T_{\max} \leq 270$ °C). Therefore, the value of (475±32) mGy for the experimental dose acquired by specimen C-3A was calculated as the difference between D_γ and D_R.

Since the contribution of the geological TL signal is rather substantial for specimen C-2, the magnitude of D_T changes appreciably, depending on the maximal temperature of the TL measurement. The amplitude of the TL signal in the case of the untreated specimen is equivalent to the residual dose of about 140 mGy. For specimen C-2C subjected to the additional thermal treatment, this residual dose decreases down to (18±12) mGy, which testifies that the TL signal was not sufficiently erased in the vicinity of 210 °C, when manufacturing this silicate brick. Therefore, the proposed method of determination of the absorbed dose will reveal a significant error for specimens of such a type, owing to an ambiguity in the determination of the residual TL signal and the plateau absence (see also Section 3.).

The most encouraging results were obtained for specimen C-1. The magnitude of the dose absorbed by specimen C-1A ((542±9) mGy), after subtraction of the dose acquired by the untreated specimen C-1D ((32±4) mGy), gives rise to (510±13) mGy. This value is very close to the experimental dose D_γ, which this specimen was irradiated with. The distributions of the measured values of D_T for both specimens are in a very good agreement with the normal distribution curve (Fig. 5). The value of the absorbed dose found for the specimen subjected to the additional thermal treatment at 200 °C for 12 h is below the sensitivity threshold of the method ($<$ 10 mGy), which confirms that the residual TL signal and the dose D_R responsible for the latter are practically absent. The value of D_γ for the specimen preliminarily subjected to the thermal treatment amounts to (487±11) mGy. Therefore, both values correlate well with the radiation dose, which the specimens were exposed to.

We succeeded in evaluating the dose D_X acquired by the silicate brick specimen C-1 subjected to the irradiation caused by the radioactive contamination. Taking into account the fact that the magnitude of the residual dose D_R can be neglected for this specimen and subtracting the dose caused by the radioactive background $D_{\rm BG} = (11 \pm 2)$ mGy from $D_T = (32 \pm 4)$ mGy, we obtained $D_X = 21 \pm 6$ mGy which is consistent with the value of 18±7 mGy obtained for a fired ceramic brick [7]. In general, the agreement between those two values is very encouraging from the viewpoint of retrospective dosimetry which is intended for the determination of the absorbed dose less than 100 mGy. However, one should bear in mind that this result was obtained in the framework of the assumption that the residual dose D_R was absent, so that, in the case where the latter cannot be neglected, the overestimation of the D_X amplitude is probable.

But if the characteristics of silicate bricks are similar over the radioactively contaminated areas downwind of the Chernobyl accident, this material can be regarded as a quite suitable material for the retrospective determination of the absorbed doses less than 100 mGy. It should be noted that, in principle, an improvement of this technique is possible; it consists in the measurement of the doses absorbed by the specimens that were screened well by the internal walls of premises. One can evaluate the mutual contribution of D_R and $D_{\rm BG}$ in such specimens and, knowing the value of D_T for them, find D_X [2].

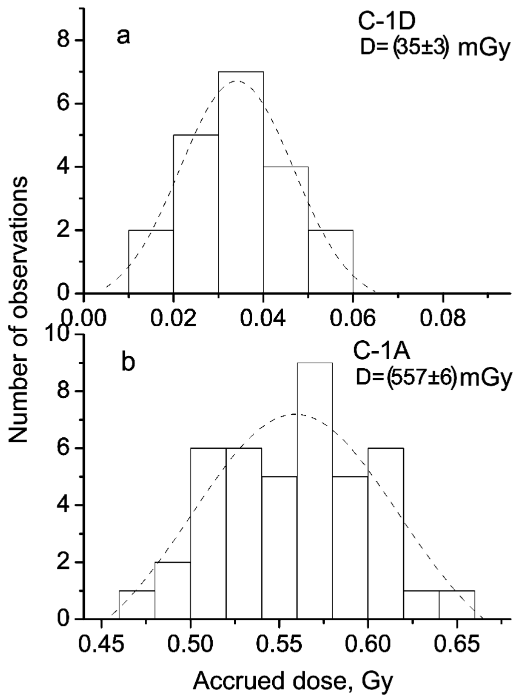

Fig. 5. Distributions of the measured values of the absorbed dose for specimens C-1D (a) and C-1A (b)

4. Conclusions

The results of this research testify that there are good reasons for considering silicate bricks as a suitable material for the retrospective measurements of the absorbed dose using the TL band of natural quartz in the vicinity of 210 °C. It is possible owing to the depopulation of traps and erasing the TL signal associated with the TL band of quartz in the vicinity of 210 °C, which can be realized by exposure silicate bricks at a rather low temperature (of about 200 °C) for long time interval (6—12 h). The sensitivity of quartz was found to be sufficient to determine the absorbed dose at a level of tens of mGy. The amplitude of the dose D_X absorbed as a result of the accidental irradiation, which has been calculated for one of the specimens, amounts to (21±6) mGy, agreeing very well with the value of (18±7) mGy obtained in the course of the previous measurements of fired bricks taken from the same building. All that considerably extends the range of materials which are suitable for the registration of the radiation dose acquired owing to the accident.

Thus, the method proposed in this work for the measurement of the absorbed dose using silicate bricks has good chances to find a wide application in retrospective dosimetry of the settlements subjected to the radiation contamination owing to the Chernobyl accident.

The researches presented in this work were funded by the European Commission in the framework of the 5-th Structural Program (1998–2002) “Nuclear fission and radiation protection”, contract FIGD-CT-2000-00094.

1. *Haskell E.H.,* Radiat. Prot. Dosim. **47**, 297 (1993).
2. *Bailiff I.K.,* Radiat. Meas. **27**, 923 (1997).
3. *Bailiff I.K.,* Radiat. Prot. Dosim. **84**, 411 (1999).
4. *Bailiff I.K., Botter-Jensen L., Correcher V. et al.,* Radiat. Meas. **32**, 609 (2000).
5. *McKeewer S.W.S.,* Thermoluminescence of Solids (Cambridge University Press, Cambridge, 1988).
6. *Constructional* Materials / Ed. by P.V. Kryvenko (Vyshcha Shkola, Kyiv, 1993) (in Ukrainian).
7. *Radiation* Fields, Dosimetry, Biokinetics and Biophysical Models for Cancer Induction by Ionizing Radiation 1996-1999 / Ed. by P. Jacob (GSF-Bericht 03/00, Neuherberg, 2000).
8. *Aitken M.J.,* Thermoluminescence Dating (Academic Press, London, 1985).
9. *Haskell E.H., Bailiff I.K., Kenner J.H. et al.,* Health Phys. **66**, 380 (1994).
10. *Petrov S.A., Bailiff I.K.,* Radiat. Prot. Dosim. **84**, 551 (1997).
11. *Göksu H.Y., Schwenk P., Semiochkina N.,* Radiat.Meas. **33**, 785 (2001).

Received 21.04.05.
Translated from Ukrainian by O.I. Voitenko

ДОСЛІДЖЕННЯ ТЕРМОСТИМУЛЬОВАНОЇ ЛЮМІНЕСЦЕНЦІЇ ПРИРОДНИХ КВАРЦОВИХ ВКЛЮЧЕНЬ У СИЛІКАТНІЙ ЦЕГЛІ З МЕТОЮ РЕКОНСТРУКЦІЇ ПОГЛИНУТОЇ ДОЗИ В РАЙОНАХ З РАДІОАКТИВНИМ ЗАБРУДНЕННЯМ ВНАСЛІДОК ЧОРНОБИЛЬСЬКОЇ КАТАСТРОФИ

В.Б. Михайлик, І.К. Бейліфф

Резюме

Досліджено можливість використання кварцових включень у силікатній цеглі з метою ретроспективної дозиметрії населених пунктів у районах, що зазнали радіоактивного забруднення внаслідок Чорнобильської катастрофи. Для визначення дози, яку набули зразки силікатної цегли внаслідок опромінення природними та штучними джерелами радіації, використано методику, що базується на вимірюванні смуги 210 °C термостимульованої люмінесценції (ТЛ) природного кварцу. Встановлено, що технологія виготовлення силікатної цегли, яка містить стадію тривалого витримування при підвищеній температурі (близько 200 °C), сприяє термічному вивільненню носіїв заряду з пасток, пов’язаних зі смугою ТЛ 210 °C, створюючи таким чином необхідні передумови для стирання геологічного ТЛ-сигналу. Показано, що ТЛ-чутливість кварцу є достатньою для вимірювання поглинутої дози, більшої за 10 мГр. При застосуванні даної методики для вимірювань зразків силікатної цегли з зони радіоактивного забруднення отримано результати, які добре узгоджуються з попередніми дослідженнями керамічної (відпаленої) цегли.