International Intercomparison of Retrospective Luminescence Dosimetry Method: Sampling and Distribution of the Brick Samples from Dolon’ Village, Kazakhstan

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Luminescence/Retrospective dosimetry/ Dolon’/Semipalatinsk/Sampling.

There are still many differences in dose estimates depending on the applied methods of retrospective dosimetry in the areas, which were affected by nuclear tests at the Semipalatinsk nuclear test site (SNTS). In order to provide more correct estimation of radiation doses to population in proximity to the SNTS an International Intercomparison of Retrospective Luminescence Dosimetry (RLD) method had been proposed. It was suggested there be a comparison of the dose estimates for the brick samples from the buildings in the settlement, suffered following nuclear tests at the SNTS. With this purpose, during the September-October 2002 field mission, the team of specialists from Kazakhstan and Japan had collected four whole bricks for RLD International Intercomparison. Three buildings were selected as sampling locations in Dolon’ village (Kazakhstan). The slices from these bricks were distributed between six laboratories in Finland, Germany, Japan, Russia, UK and USA for independent estimations by the RLD method of the accumulated dose of external irradiation.

The descriptions of sampling, locations, data on geographical coordinates, dates of building construction, mode of cutting of samples for distribution, labeling, condition of transportation, order of the distribution of samples and information concerning $^{137}$Cs and $^{239+240}$Pu soil contamination density in the village and near sampling locations are presented in the paper.

INTRODUCTION

The correct estimation of radiation doses to population in proximity of Semipalatinsk nuclear test site (SNTS) is one of the important issues in studying the health consequences of nuclear tests. There are still many differences in dose estimates depending on which methods of retrospective dosimetry are applied: calculations, luminescence measurements of quartz inclusions in the bricks, electron spin resonance (ESR) tooth enamel dosimetry, biological dosimetry data.1–5 In the course of discussions during the International Symposium (2002 year) in Semipalatinsk (Kazakhstan)1 and the International Symposium in Hiroshima, Japan, (March, 2004 year)3 the following action was proposed: to perform an International intercomparison of the Retrospective Luminescence Dosimetry (RLD) method using samples from the same bricks collected in Dolon’ village (Semipalatinsk region, Kazakhstan).

Four whole bricks were extracted from the walls of three buildings located on the southeast of Dolon’ village. The documented slices from these bricks were distributed between six laboratories in Finland, Germany, Japan, Russia, UK and USA for measurements of accumulated absorbed dose by the RLD method and for the subsequent intercomparison of the obtained experimental results. It was planned that the data from this instrumental estimation of external accumulated dose would be used for comparison with calculated dose values for Dolon’ village and with the
results of ESR tooth enamel dosimetry for this settlement.

MATERIALS AND METHODS

The village of Dolon’ (N 50°39’; E 79°18’) is one of the most affected inhabited settlements within the regions of highest predicted dose as a result of nuclear tests at the SNTS,\(^6,7\) mainly as a result of the 29 August, 1949 nuclear test (see Fig. 1\(^4\)).

In order to provide the materials for the RLD International Intercomparison, the four whole bricks were collected from three buildings in Dolon’ village. The sampling had been completed during September-October 2002 field mission. The following buildings, which had been constructed before the 29 August 1949 nuclear test, were selected as sampling locations: location “School”, sample KSD 4-1 (1 brick, see Fig. 2), location “Small church”, sample KSD 3-2 (1 brick, see Fig. 3) and location “Large church”, sample KSD 1-3 and sample KSD 2-1 (2 bricks, see Fig. 4). All of these buildings are located relatively close to each other on the

![Fig. 1. Location of Dolon’ village in the vicinity of the radioactive plume from the 29 August 1949 nuclear test (indicated by ------) in comparison with locations of other nearest settlements in Kazakhstan and Russia. NTS – Semipalatinsk nuclear test site. 1,2,3,4 - the solid contour values corresponding to the following levels of expected cumulative dose as a result of the 29 August 1949 nuclear test\(^4\): 1 (250 mSv); 2 (50 mSv); 3 (10 mSv); 4 (1 mSv).]

![Fig. 2. In left picture: general view of the location “School” (N 50°39’49’’; E 79°18’51’’) Dolon’ village. In right picture: location “School”, Dolon’ village. The brick was extracted from the upper part of the basement (sample KSD 4-1). The left surface of the brick is located at the distance of 95 cm from the left corner of the basement. The distance between bottom surface of the brick and the ground level is 70 cm. The top surface of the brick was covered by mortar with 4 cm thickness. The total height of the basement is 81 cm. The building was constructed from wood. The height of the building is 5.5 m (from the ground level to the roof).]
southeast of Dolon’ village (see Fig. 5). The positions of all locations were determined by GPS. The description of soil sampling and methodology of measurements of $^{137}$Cs and $^{239+240}$Pu activity is presented in the paper.  

**RESULTS**

After extraction from the walls, all the collected bricks
were labeled with indication of the external surface, top surface and orientation of the bricks in the walls. The extracted whole bricks were wrapped in a black material and were sent by post from SRIRM (Semipalatinsk, Kazakhstan) to MRRC of RAMS (Obninsk Russia).

At MRRC each obtained brick was cut by low speed water lubricated diamond saw into seven slices in the direction from the external surface (“front”) to the back surface (see Figs. 6, 7, 8, 9). Each slice for each brick was labeled with indication of the external (“front”) surface, top surface, position, and orientation of the slices in the brick (see Fig. 10 as an example).

All work at MRRC was performed under “red light”. After cutting all the slices were wrapped in a black material and five slices from each brick were delivered by car from the MRRC (Obninsk, Russia) to the Dating Laboratory (University of Helsinki, Finland). The corresponding figures

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**Fig. 5.** Sampling locations on the southeast in Dolon’ village: “School” (N 50.664°; E 79.314°), “Small Church” (N 50.661°; E 79.312°), “Large Church” (N 50.662; E 79.309°). Supposed position of the centerline of radioactive trace was determined as described in the paper.16)

**Fig. 6.** Slices (from 1 to 7) of the brick from location “School”, sample KSD 4-1.

**Fig. 7.** Slices (from 1 to 7) of the brick from location “Small church”, sample KSD 3-2.

**Fig. 8.** Slices (from 1 to 7) of the brick from location “Large church”, sample KSD 1-3.

**Fig. 9.** Slices (from 1 to 7) of the brick from location “Large church”, sample KSD 2-1.

**Fig. 10.** An example of labeling of slice “2” (from the sample KSD 4-1, location “School”), which was distributed to labs in Japan.
with the indication of bricks, slices, labels and dimensions were provided to participants in paper form and by e-mail. Two slices from each brick were left at MRRC, Russia, in the “dark room” – one slice for the luminescence measurement and one archive slice. Four slices from each intercomparison brick were sent by Express mail from Dating Laboratory (University of Helsinki, Finland) to RIRBM (Hiroshima University, Japan), National Cancer Institute (USA), Luminescence Laboratory of the Environmental Research Centre (University of Durham, UK), GSF-Forschungszentrum für Umwelt und Gesundheit, Institut für Strahlenschutz (Neuherberg, Germany). One slice from each intercomparison brick was left in the Dating Laboratory (University of Helsinki, Finland) for luminescence measurements.

Each laboratory was provided with cut slices of the same bricks collected at different locations in order to avoid differences in the results of RLD measurements due to different material and radionuclide composition of the samples, or due to different geometry of sampling.

The order of distribution of the samples between Labs with indication of all labels is presented in Table 1. The distribution of all samples was finished in June, 2003.

During the field mission in Dolon’ village (September-October 2002), the soil sampling and measurements of geographical coordinates by Global Positioning System (GPS) were performed by teams of specialists from Japan and Kazakhstan. The corresponding GPS data related to brick sampling sites are presented in this paper.

Information on the ages of the buildings, which were selected for brick sampling, is presented in Table 2. It should be noted that this information is based on the questioning of local inhabitants. The estimation of the age of “large church”, which is based on the archival records and on the results of luminescence measurements of well-shielded brick from “large church” and background dose rate estimations for this brick is presented in the same table.

### DISCUSSION

It is notable that data concerning $^{137}$Cs soil contamination density near brick sampling locations presented in the recent paper Sakaguchi et al. (see Fig. 11 as well) are in agreement with the previously published data. $^{137}$Cs soil contamination density (adjusted to 1989 year) was estimated to be in the range from 0.74 kBq/m$^2$ to 3.74 kBq/m$^2$ for soils on the southeast of Dolon’.

The information about “ages” of the buildings, which were selected for brick sampling, was obtained by questioning of local inhabitants. As far as this information is important for background dose estimation, additional searching of archival records is desirable in order to obtain more exact information concerning buildings’ “ages”. Additional sampling of well-shielded bricks from the same buildings would be very useful as well. These brick samples may be used for direct background dose estimations by the RLD method.

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**Table 1.** Distribution of the brick slices between six Labs in different countries.

| Country | Slices of the sample KSD 4-1, location “School” | Slices of the sample KSD 3-2, location “Small church” | Slices of the sample KSD 1-3, location “Large church” | Slices of the sample KSD 2-1, location “Large church” |
|---------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Finland | 5                                             | 7                                             | 5                                             | 6                                             |
| Germany | 3                                             | 3                                             | 3                                             | 3                                             |
| Japan   | 2                                             | 2                                             | 2                                             | 7                                             |
| Russia  | 6                                             | 5                                             | 6                                             | 5                                             |
| UK      | 4                                             | 4                                             | 4                                             | 2                                             |
| USA     | 1                                             | 1                                             | 1                                             | 1                                             |

**Table 2.** Information on the ages of the buildings, which were selected for the brick sampling.

| Location     | Year of building according to questioning | Year of building according to archive records | Year of building according to the luminescence measurements of shielded brick and background dose rate estimations for this brick |
|--------------|------------------------------------------|-----------------------------------------------|----------------------------------------------------------------------------------|
| School       | 1930                                     | –                                             | –                                                                               |
| Small church | 1920                                     | –                                             | –                                                                               |
| Large church | 1898                                     | 1904                                          | 1902 ± 5                                                                         |
It should be noted that during the period from 1997 to 1999 the bricks from “large church” had been collected as well by the scientists from RIRBM (Hiroshima University) and by the specialists from the EU supported Measurement Group (Durham University, GSF, University of Helsinki, MRRC of RAMS). The results of dose estimations obtained by the RLD method have been published. A value of about 2 kBq/m² for 137Cs global fallout in the Semipalatinsk region was subtracted from the values shown in this figure on the basis of 137Cs soil contamination data presented in the paper, which are related to the territories near Almaty (Kazakhstan) located far from the SNTS. All 137Cs activities were adjusted to 1992 year.

SUMMARY AND CONCLUSIONS

The four brick samples for International Intercomparison of the RLRD method were collected in the most affected inhabited settlement as a result of nuclear tests at the SNTS – the village of Dolon’, Semipalatinsk region, Kazakhstan. The labeled and documented slices of the extracted bricks were distributed between six laboratories in Finland, Germany, Japan, Russia, UK and USA. The selected mode of cutting and transportation was able to avoid heating and exposing of the samples to day/sun-light. Each laboratory was provided with cut slices of the same bricks collected at different locations to avoid differences in the results of RLD measurements due to different material and radionuclide composition of the samples, or due to different geometry of sampling. The geographical coordinates of sampling locations, positions and orientation of the bricks in the walls for all locations were documented as well. The information concerning 137Cs and 239+240Pu soil contamination density in the village and near sampling locations is presented in this paper. Additional sampling of well shielded bricks from the same
buildings would be very useful for independent background dose estimations by the direct RLD method. In any case the collected samples could be used for International Intercomparison of different RLD procedures.

ACKNOWLEDGEMENTS

The work described here was partially supported by Grant-in-Aid for Scientific Research (B) from Japan Society for the Promotion of Science (JSPS) No 15406002 and by the institutes of the authors. One of the authors (VFS) acknowledges financial support from JSPS and Hiroshima University to attend Hiroshima University and the 3rd Dosimetry Workshop on the Semipalatinsk Nuclear Test Site Area at which this paper had been presented.

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J. Radiat. Res., Vol. 47, Suppl. A (2006); http://jrr.jstage.jst.go.jp