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

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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 Luminescnence 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

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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

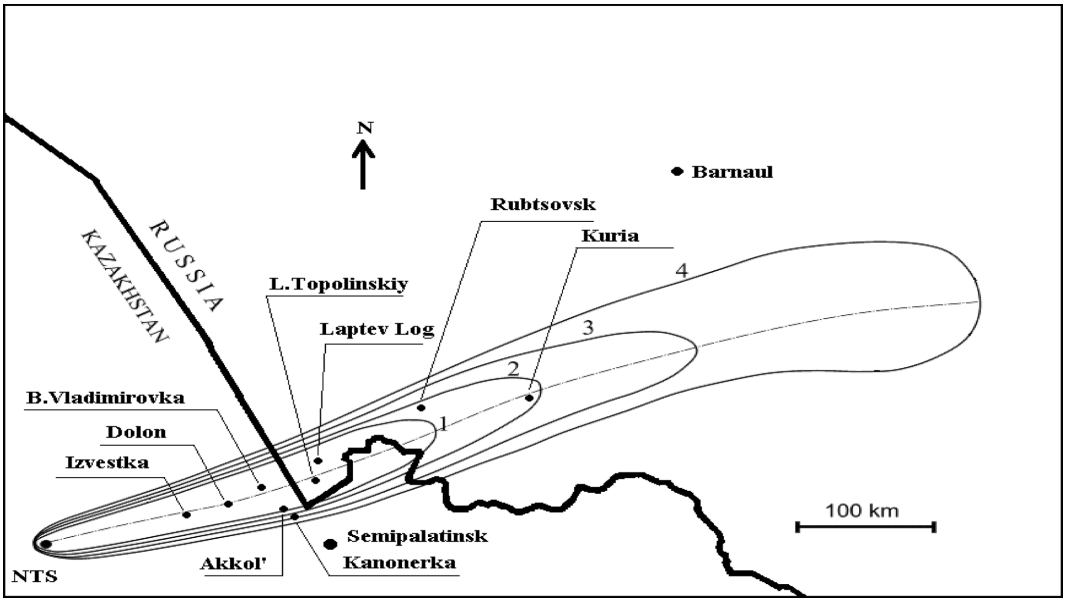

Fig. 1. Location of Dolon' village in the vicinity of the radioactive plume from the 29 August 1949 nuclear test (indicated by ------) in comparison with locations of other nearest settlements in Kazakhstan and Russia. NTS – Semipalatinsk nuclear test site. 1,2,3,4 - the solid contour values corresponding 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).

Fig. 3. **In left picture**: general view of location "Small church" (N 50°39'39''; E 79°18'42''), Dolon' village. The first floor of the building was constructed from bricks, the second floor – from wood. The length of front wall is 14 m. Total height of the building is 6 m (from the ground level to the roof), the height of the first floor is 3 m. Mean thickness of the mortar on the wall is about 1 cm. The left side of the left window and the right side of the right window are located at the distance of 170 cm from the left and the right edges of the wall, consequently. The width of the left window is 130 cm; the width of right window is 95 cm. The height of these windows is 130 cm. The width of the central window is 150 cm; the height of the central window is 110 cm. The distance between the upper edges of the windows and the ground level is 225 cm. **In right picture**: location "Small church", Dolon' village. The bricks from the wall, which is located to the right from the central window, were selected for the sampling. The lower brick was selected for International Intercomparison (sample KSD 3-2). The distance between the left surface of KSD 3-2 brick and the right side of the central window is 33 cm. The distance between the bottom surface of KSD 3-2 brick in the wall and the ground level is 107 cm.

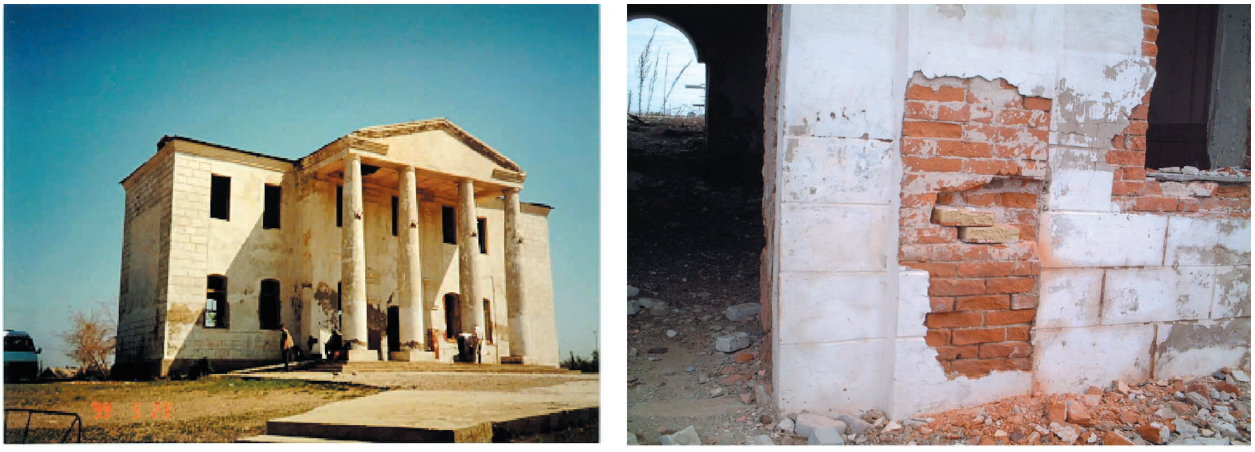

Fig. 4. **In left picture**: general view of location "Large church" (N 50°39'42''; E 79°18'34''), Dolon' village. The detailed description of the building is presented in the reference.[4] **In right picture**: location "Large church", Dolon' village. The bricks from the wall to the right from the central entrance were selected for the sampling (sample KSD 1-3 and sample KSD 2-1 – lower brick). The portico of the building was constructed several years after the nuclear test on 29 August 1949. The distance between the left surface of KSD 1-3 brick and the right side of the central entrance is 82 cm. The distance between the left surface of KSD 2-1 brick and the right side of central entrance is 94 cm. The distance between the bottom surface of KSD 1-3 brick and the floor of the portico is 111 cm. The distance between the bottom surface of KSD 2-1 brick and the floor of the portico is 102 cm. The height of the central entrance is 3 m; the width of the central entrance is 2 m. Mean thickness of the mortar on the wall is about 1.5 cm.

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.[8]

RESULTS

After extraction from the walls, all the collected bricks

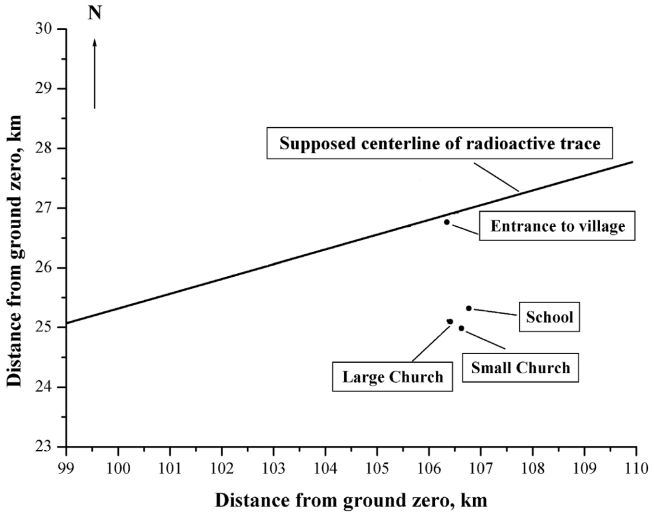

Fig. 5. Sampling locations on the southeast in Dolon' village: "School" (N 50.664°; E 79.314°), "Small Church" (N 50.661°; E 79.312°), "Large Church" (N 50.662; E 79.309°). Supposed position of the centerline of radioactive trace was determined as described in the paper.[16)]

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

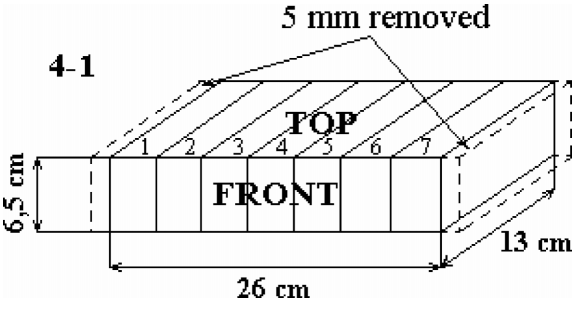

Fig. 6. Slices (from 1 to 7) of the brick from location "School", sample KSD 4-1.

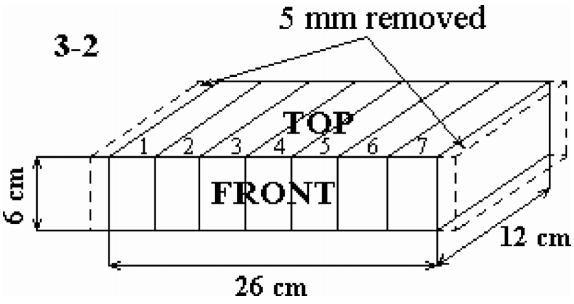

Fig. 7. Slices (from 1 to 7) of the brick from location "Small church", sample KSD 3-2.

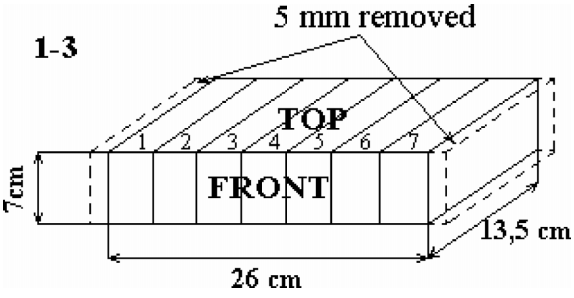

Fig. 8. Slices (from 1 to 7) of the brick from location "Large church", sample KSD 1-3.

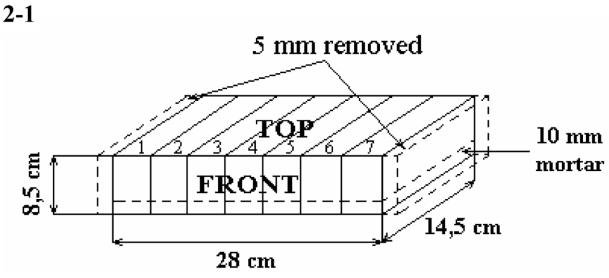

Fig. 9. Slices (from 1 to 7) of the brick from location "Large church", sample KSD 2-1.

Fig. 10. An example of labeling of slice "2" (from the sample KSD 4-1, location "School"), which was distributed to labs in Japan.

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

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.[8] 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 the sampling of the intercomparison bricks, 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[4,9] 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*.[8] (see Fig. 11 as well) are in an agreement with the previously published data.[4,10,11,12] According to these 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.

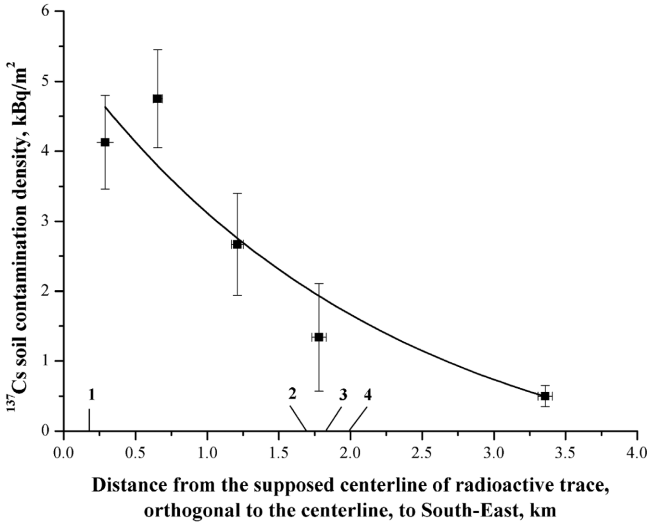

Fig. 11. Dependence of ^{137}Cs soil contamination density in Dolon village vs distance from the supposed centerline to the SE[16] (the distance "0" corresponds to the supposed centerline of the trace). The filled squares are experimental data and errors are given at a 68% level of confidence. The spatial intervals of soil contamination averaging are equal to 500 m. The solid line represents an approximation obtained by non-linear fitting of exponential function to experimental data. The numbers indicate various locations where "1" is the entrance to village (0.193 km), "2", "3", "4" are the school (1.7 km), large church (1.83 km) and small church (1.93 km) respectively, and correspond to locations where brick samples were obtained for testing by the RLD method. Supposed position of the centerline of radioactive trace was determined as described in the paper.[16] A value of about 2 kBq/m^2 for ^{137}Cs global fallout in the Semipalatinsk region was subtracted from the values shown in this figure on the basis of ^{137}Cs soil contamination data presented in the paper,[8] which are related to the territories near Almaty (Kazakhstan) located far from the SNTS. All ^{137}Cs activities were adjusted to 1992 year.

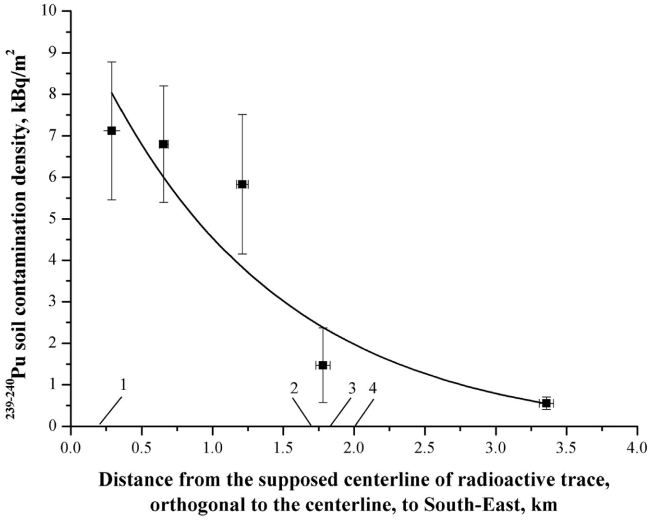

Fig. 12. Dependence of $^{239+240}$Pu soil contamination density in Dolon village vs distance from the supposed centerline to the SE[16] (the distance "0" corresponds to the centerline of the trace).[16] The filled squares are experimental data and errors are given at a 68% level of confidence. The spatial intervals of soil contamination averaging are equal to 500 m. The solid line represents an approximation obtained by non-linear fitting of exponential function to experimental data. The numbers indicate various locations where "1" is the entrance to village (0.193 km), "2", "3", "4" are the school (1.7 km), large church (1.83 km) and small church (1.93 km) respectively, and correspond to locations where brick samples were obtained for testing by the RLD method. Supposed position of the centerline of radioactive trace was determined as described in the paper.[16] The global fallout level of $^{239+240}$Pu was neglected in the data shown in this figure.

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)[13,14] and by the specialists from the EU supported Measurement Group (Durham University, GSF, University of Helsinki, MRRC of RAMS).[4] The results of dose estimations obtained by the RLD method have been published.[4,13,14] It is notable that radioactive trace of 29 August, 1949 nuclear test is very narrow in the vicinity of Dolon' village,[6,9,15,16] which results in heterogeneity of local soil contamination by ^{137}Cs and $^{239+240}$Pu (see Fig. 11 and Fig. 12) and, consequently, in heterogeneity of local dose values inside the settlement. The data obtained by RLD method are important for estimation of local doses in the settlement.

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 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 geographical coordinates of sampling locations, positions and orientation of the bricks in the walls for all locations were documented as well. The information concerning ^{137}Cs and $^{239+240}$Pu soil contamination density in the village and near sampling locations is presented in this paper. Information concerning "ages" of the buildings was provided on the base of questioning of local inhabitants. As far as this information is important for background dose estimation, additional search in archival records is desirable. 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.

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