Ministério da Ciência e da Tecnologia
Instituto Tecnológico e Nuclear
Departamento de Protecção Radiológica
e Segurança Nuclear

Final Report

Report of the Portuguese Scientific Mission to Kosovo and to Bosnia-Herzegovina for assessment of radioactive contamination and of the radiological risk due to the use of depleted uranium ammunitions

April 17th, 2001

Estrada Nacional 10, Apartado 21, 2686-953 Sacavém, Portugal

MCT – Ministério da Ciência e Tecnologia

INSTITUTO TECNOLÓGICO E NUCLEAR

Departamento de Protecção Radiológica e Segurança Nuclear

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FOREWORD

This Final Report on the investigation relating to contamination with depleted uranium (DU) in Kosovo and in Bosnia-Herzegovina, and on the DU-related radiological risk to the Portuguese military on duty there, was carried out by the Departamento de Protecção Radiológica e Segurança Nuclear (Radiological Protection and Nuclear Safety Department) of the Instituto Tecnológico e Nuclear (Nuclear and Technological Institute) and presented to His Excellency the Ministro da Ciência e da Tecnologia (Minister of Science and Technology) on April 17th, 2001.

The objective of this report, which aims to be as complete as possible, is to answer the questions and concerns that led to the investigation.

For this purpose, the Report includes:

- The presentation of the results from the analysis of all samples collected by the Portuguese Scientific Mission to the Balkan Region, thus completing the first results presented in the Preliminary Report issued on February 5th, 2001.
- A comprehensive assessment of the DU contamination of military, police officers and civilians that have served in the Balkan region, through the analysis of urine samples collected at the military hospitals, as part of the medical survey. The results obtained have already been forwarded to the military hospitals.
- Evaluation of particular cases of military and police officers who have fallen ill or deceased, where the Department's collaboration in radioactivity-related analysis was requested. The results of these examinations have already been reported to the medical authorities in the armed services and their agreement for public disclosure has been granted.

ITN/DPRSN

1 INTRODUCTION

In the Balkan military conflict, ammunitions containing a depleted uranium (DU) penetrator were used in the aerial bombardments. Uranium is a metal and in addition to other extraordinary properties, is radioactive.

Following the NATO bombings, cases of leukaemia and other pathologies were diagnosed amongst the military of the multinational peacekeeping forces deployed in the Balkan region. It was suggested that the DU used in the making of the ammunitions might have caused the leukaemia. DU was also feared to have been the cause of widespread environmental contamination of the Balkans, potentially causing a significant exposure to uranium-borne radioactivity involving the civilian population and the military contingents.

The effects of DU became a general concern of the public in several countries, including Portugal. The possibility that Portuguese military personnel involved in a United Nations peacekeeping mission might be exposed to radiation and to the chemical toxicity of DU was pointed out.

In the absence of measurements and of appropriate analysis, the Departamento de Protecção Radiológica e Segurança Nuclear (DPRSN) of the Instituto Tecnológico e Nuclear (ITN), with technical and scientific competence in this matter, was available to assess the alleged radioactive contamination and the radiological risk in the Balkans. By Order[1] of HE the Minister of Ciência e Tecnologia of January 4th, 2001, official approval was given for a technical and scientific mission made up of a three-strong team from the ITN-DPRSN. The Estado Maior General das Forças Armadas (EMGFA) appointed three other staff, one of them a military doctor, to accompany this mission.

The overall objectives of the mission were:

1. To monitor the exposure and the radioactive contamination sources at the sites where Portuguese military barracks are installed or were installed in the past, and to identify any radioactive contamination;
2. To collect samples of soil, foodstuffs, water and aerosols for laboratory analysis, including the determination of the concentration of uranium isotopes;
3. To collect urine samples from Portuguese military and Portuguese police officers from the International Police Task Force (IPTF) on duty in the Balkans in order to evaluate any internal contamination that might be due to DU.

[1] MCT order nº 4759/2001, Diário da República nº 57, II Série, March 8th, 2001.

2 MISSION TO KOSOVO AND TO BOSNIA-HERZEGOVINA

The mission[2] to Kosovo lasted from January 5th to the 10th, 2001, and to Bosnia-Herzegovina from January 10th to the 19th, 2001 (see Figures 1, 2 and 3).

The necessary equipment for field work was carried with the scientific team, and this included 12 portable radiation monitors (beta-gamma probes, alpha probes, ionisation chambers and a portable gamma spectrometer), radioactive sources for instrument testing, equipment for water and soil collection, a high-volume atmospheric particle collector and individual protection equipment, including masks and garments.

In Kosovo, the team stayed at the Portuguese military headquarters in Klina and benefited from their logistic support. From January 5th to the 9th 2001, fifty-two sites were monitored in Kosovo. In some sites (e.g. the Klina headquarters) radiation measurements were taken at several points, thus increasing the total number of sites monitored.

The majority of the sites monitored correspond to the areas where Portuguese military patrols were most frequently carried out. However, also included in the monitoring were some spots identified by the KFOR as bombing targets where DU ammunitions had been used, places where other ammunition types were used and sites where no significant military action had taken place, i.e. agricultural areas and cities. Examples of sites monitored were Prlina, Pec, Djakovica, the Monastery of Budisavci, Volujak, Duz, Prizren, Pristina and Mitrovica.

On January 10th, the team moved from Kosovo to Sarajevo in Bosnia-Herzegovina (BiH), and stayed in the town of Visoko, a few kilometres from Portuguese military headquarters.

Thirty-six sites were inspected and monitored from January 11th to the 19th. In some sites, as in Visoko (town and military headquarters), external radiation measurements were performed and samples were collected from several points. All sites monitored correspond to places where Portuguese military and Portuguese IPTF agents were living or had been living in the past, such as Visoko, Breza, Rogatica, Goradze, Jabuka, Ustipraca, Visegrad, Doboj, Zetra (Zehra Muidoviç), Sarajevo and Mostar. The team also inspected points identified by the SFOR as former DU bombing targets and also villages, industrial and rural areas.

The ITN-DPRSN team visited and carefully monitored several places in BiH, such as former Serbian artillery positions in the hills around Sarajevo bombed by the NATO forces. No DU fragments were detected. In just two places, the barracks of the Italian brigade in Tito Barracks (formerly the Military Academy), and the ex-Serbian war factory in Hadzici, fragments of DU were observed and the radioactivity emitted was monitored.

[2]A detailed description can be found in the Preliminary Report of the Scientific Mission, February 5th, 2001. http://www.itn.pt/

In the Sarajevo region, the expert mission was able to visit and interview medical doctors from civilian hospitals, to gather information on the incidence of leukaemia and other types of cancer in the local population. Specifically, the Clinical Centre of the University of Sarajevo (Haematology), the Cancer Centre and the Ministry of Health of BiH were visited. The collaboration of the Portuguese Diplomatic Mission in Sarajevo in organising these meetings is gratefully acknowledged.

The team of experts was also requested to participate in meetings for information exchange and discussion on the monitoring programme with the German military NBC brigade of the SFOR, stationed at Camp One Carreau, Rajlovac; with the Medical-Colonel of the Danish Company of the Dannervique Camp; with the Irish military authorities (Gen. Kelly and the Medical-Colonel M. Murphy); and with several representatives of Diplomatic Missions in Sarajevo. In all these meetings, there was widespread interest in the results of this work, as well as in a complete understanding of the radio-toxicological health risks to the military and the civilian populations resulting from the use of DU ammunitions.

Once the field trip was concluded, all the samples collected were analysed at the DPRSN laboratories in Sacavém, Portugal.

3 MATERIALS AND METHODS

3.1 Field measurements

All the sites where radiation measurements were performed and samples collected are identified by their respective geographical coordinates determined with a portable GPS (see Tables 1 and 2 and Figures 4 and 5).

Measurements of external radiation level and of surface contamination were carried out with portable radiation monitors, i.e. ionisation chambers, Geiger-Müller counters and alpha probes. Prior to the mission, the equipment was calibrated at the ITN-DPRSN Laboratório de Metrologia das Radiações Ionizantes (Ionising Radiation Metrology Laboratory), where national radioactivity and radiation standards are kept. During the field trip the detectors were frequently tested, using test sources. In several places a portable gamma spectrometer based on a NaI(Tl) detector was used and the spectra were collected on a portable multi-channel analyser with an internal radionuclide library.

3.2 Sample collection

Soil samples were collected using a stainless steel 6-cm diameter tube. On each site, three soil samples of the superficial layer (0-5 cm) were collected from inside a 50 m radius circle. The three samples were mixed together in order to get a representative sample of the soil in that area, and analysed by gamma spectrometry and by alpha spectrometry.

Atmospheric particles (aerosols) were collected in several places using a high-volume sampler (60 m^3/h), large-area glass fiber filters and 24-hour sampling time.

Samples of water were collected from the public water supply, from the water used in the Portuguese barracks and from the rivers, both in Kosovo and in BiH. The samples were acidified on the spot to pH<2 with HNO_3.

In Kosovo, fifty-two soil samples, three aerosol samples, foodstuffs from five different places and nine water samples from rivers and from the public network supply systems were collected for laboratory analysis. Urine samples were collected from forty persons, e.g., military, IPTF elements and civilians from the local population. Twenty personal thermoluminescent dosemeters were also distributed to military and police officers and used for one month.

In Bosnia-Herzegovina, thirty-four soil samples and six aerosol samples were collected, locally produced foodstuff was bought in five different towns, eight water samples were taken from the public water supply and from the river Bosnia, and urine samples from thirty-nine military personnel and ITPF staff were collected. Forty personal dosemeters were distributed to military personnel, ITPF police officers and members of the Portuguese Diplomatic Mission in Sarajevo.

Representative samples of the current diet were obtained in various towns where foodstuff was bought at the local markets. Just a few samples of the diet of Portuguese military personnel were collected for analysis since nutrition is almost always brought directly from Portugal or provided through the NATO supply system. NATO supplies are generally of Italian origin though vegetables usually come from Croatia. Only bread is locally produced in Kosovo and in BiH, and the making is supervised respectively by KFOR and SFOR.

3.3 Analytical Methods

3.3.1 Radiation dosimetry (personal monitoring of external radiation)

The method used for the evaluation of the external radiation dose received by the members of the scientific team and military personnel was identical to the method used by the DPRSN for the evaluation of the radiation dose received by professionally exposed workers. The methodology is based on thermoluminescence detectors (TLD).

The results reported herein are expressed in terms of the Hp (10), the personal dose equivalent penetrating, the operational quantity used in Radiological Protection to estimate the effective dose. In Portuguese Law (Decreto-Regulamentar nº 9, April 19th, 1990), the annual dose limit for classified workers is 50 mSv and 5 mSv for public exposure. European Union directive 96/29/EURATOM, soon to be incorporated into Portuguese legislation, stipulates that the annual limit for classified workers should not exceed 100 mSv over a 5-year period, provided that 50 mSv is not exceeded in any one year. The directive also establishes an annual dose limit of 1 mSv for public exposure.

For this work, a set of 126 TLD dosemeters were prepared. The dosemeters were identical to the ones used by the professionally exposed workers in the country for the evaluation of the X and gamma radiation dose. Measurement and control dosemeters were considered. The control dosemeters were used to estimate the contribution to the total dose apart from the field dose, e.g., the background and cosmic dose integrated during the trip to the Balkans.

TLD dosemeters were assigned to the members of the DPRSN and EMGFA scientific team and to press reporters. TLD dosemeters were also assigned to military personnel from the Portuguese armed forces, to Portuguese ITPF police officers deployed in Kosovo and in BiH, to staff of the Portuguese Diplomatic Mission and of the United Nations in Sarajevo.

A set of thirty-six TLD dosemeters that were taken to the Balkans but were not individually assigned, were used as controls. After a reset cycle, these TLDs were assigned to military of the EMGFA-CAq and COFT in the Lisboa area, and were used in February 2001 for comparison purposes.

3.3.2 Analysis of radionuclides by spectrometry

Laboratory analysis for the determination of gamma-emitting radionuclides are made in fresh food (gamma emmiters) and are preceded by incineration for foodstuff samples (alpha emmiters) and by drying followed by seiving for the soil samples (gamma and alpha). The results are expressed in Bq kg^{-1} (fresh weight) for food and tissues; in Bq kg^{-1} (dry weight) for radionuclides in soils and aerosols; and in Bq L^{-1} for liquid samples (water and urine). The detectors used are of the Hiperpure Germanium (HpGe) type with lead shielding for natural radioactive background suppression. The set of HpGe detectors allow the identification of the gamma photo-peaks in the energy range varying from 15-30 keV (depending on the detector) up to 2000 keV. The energy range includes every natural family gamma emmiters, uranium fission products, and primordial and cosmic origin radionuclides (Gilmore and Hemingway, 1995).

Alpha spectrometry analysis was performed after spike of the sample with an isotopic tracer (U-232 for uranium, Pu-242 for plutonium), total dissolution in acids (food, aerosols, soils and tissues), precipitation (water, urine), chemical separation of the nuclides by ion exchange in chromatographic column and finally electroplating on stainless steel disks to be used as thin alpha sources. The determination of alpha radioactivity is done with surface barrier silicon detectors, with a very low background and a high resolution, operated inside vacuum chambers. The detection limit of uranium in urine samples is about 1 ng L^{-1}, or less, depending on the counting time used (Ivanovich and Harmon, 1982).

The high resolution alpha spectrometry for uranium analysis allows the proper identification of every uranium isotope and determination of isotopic ratios. It should be noted that natural uranium is composed of three isotopes whose properties and proportions are

quoted on the table below. In depleted uranium, the isotopic proportions are modified, with the U-235 reduced to 0.20 % of total (Fulco *et al*, 2000). For instance, on a soil not altered by depleted uranium contamination and whatever the total uranium concentration is (depending on the soil composition) the proportions of the uranium isotopes are usually constant.

	Natural uranium			Depleted uranium	
Isotope	Period (years)	Abundance (% mass)	Activity (%)	Abundance (% mass)	Activity (%)
^{238}U	4.5×10^{9}	99.285	48.9	99.799	84.7
^{235}U	7.1×10^{8}	0.710	2.2	0.200	1.1
^{234}U	2.5×10^{5}	0.005	48.9	0.001	14.2
Isotopic Ratios					
$^{235}U/^{238}U$		0.00725		0.002	
$^{234}U/^{238}U$		5.5×10^{-5}		1.00×10^{-5}	

Density: 19.07
Melting point: 1132 ºC
At powder form it starts burning at 600 ºC (pyrophorus)
Specific activity for 1mg of natural uranium: 25.28 Bq
Specific activity for 1mg of depleted uranium: 14.66 Bq
Average uranium contents on earth crust: 3 mg/kg
(Neghabian, 1991).

The average isotopic ratios for natural uranium in the earth's crust may be used as a standard and so we shall compare against this standard the results for the Balkans samples in order to assess whether or not there is a significant presence of depleted uranium.

It should be noticed that depleted uranium is about 40% less radioactive than natural uranium, although the chemical behaviour is the same for both and so is their chemical toxicity (Fulco *et al*., 2000).

3.3.3 Uranium survey by low background beta spectroscopy

The Department was asked to co-operate in a medical survey of all military and IPTF personnel, who had at any time served in the Balkans, by analysing the presence of uranium in urine samples. It is well known that in internally contaminated individuals this element deposits in the skeleton and is gradually eliminated. So even a long time after contamination occurs, urinary excretion usually makes it possible to detect whether a significant uranium accumulation in the body of an individual has occurred or not (Legget and Harrison, 1995), (Hooper *et al*., 1999).

In order to carry out the survey for a large number of individuals (it was estimated that 5000 would have to be analysed) a quicker method than alpha spectrometry was chosen, also appropriate to uranium detection based on urinary excretion analysis in a mass screening programme

Most of the samples were collected by the military hospitals for the purpose of identifying abnormal values of beta radiation indicating internal contamination by uranium. From a 24-hour sample, 1 litre is chemically treated and uranium is separated and isolated from radioactive matters in urine, by phosphate induced precipitation in an alkaline medium (adapted from Erickson, 1997). The uranium and progeny ^{234}Th and ^{234}Pa precipitate is deposited on a sample planchet and uranium concentration is assessed through the beta radiation from uranium progeny. Total beta radiation is measured by low background proportional counters, gas flux, Canberra HT-1000, which has an efficiency of 23% for ^{40}K.

The reproducibility of the method was tested using a mixed sample of urine with 10 litres, from which 10 aliquots (1 litre each) were collected and analysed by the same method. The average value of the total beta measurement was 2.13±0.55 net cpm L^{-1} (net counts per minute, per litre).

3.3.4 Biological dosimetry by cytogenetic methods

If there is a suspicion that exposure to ionising radiation has occurred and if the exposed individual was not using a personal dosemeter (meaning he was not wearing a personal dosemeter at the time of irradiation), and in case the exposure might be the result of several types of radiation (alpha, beta, gamma), the only way to confirm or deny the suspicion about over-exposure is to require biological dosimetry. In this field of dosimetry, the peripheral blood lymphocyte genome of the individual is used as a dosemeter, as it is known that ionising radiation induces chromosome damage (dicentric) and that the frequency of the damage is proportional to the radiation dose. The analysis of this damage may lead to the conclusion as to whether or not the radiation exposure did occur and the dose can be assessed. This technique has a threshold of 100 mGy for gamma radiation and of 10 mGy for alpha and neutrons.

The count of the chromosomal aberrations in the peripheral blood lymphocyte is, amongst the biological methods, the most sensitive for the radiation dose assessment and is recommended by the International Atomic Energy Agency (IAEA, 1986).

3.3.5 Analytic quality

Besides internal quality control through repeatability tests for radioactivity analysis in well-known materials, or from aliquots of a well homogenised material, the DPRSN regularly participates in external control of analytic quality.

To this end, the DPRSN periodically participates in international analytic intercomparison exercises organised by the World Health Organisation (WHO), the IAEA and other organisations. Basically these exercises consist of analysis of samples of unknown composition simultaneously sent to several laboratories. The participating laboratories report

the analytic results and can assess the accuracy and precision of their performance in a report published after the end of the exercise (Table 3). The results from these exercises ensure the reliability of DPRSN determinations.

Examples are:

a) the external dose assessment by thermoluminescence dosimetry is reliable for gamma and X radiation, both for low, medium and high radiation levels (Figure 6);

b) the gamma emitter isotopes determination by HpGe detectors is reliable and the quality of the DPRSN results for food, soil, sediments and other materials has been demonstrated (Figures 7 and 8);

c) the alpha spectrometry accuracy is often demonstrated, including the determination of each of the uranium isotopes, particularly relevant in the present depleted uranium problem (Figures 9, 10 and 11).

The quality of the analytical work is of the utmost importance to demonstrate the reliability of the results. The DPRSN pays increasing attention to this field. This is evident from the following information:

- the environmental samples radioactivity analysis laboratory is included in a world network (ALMERA) recognised by IAEA as competent and a participant in annual intercomparisons;
- the Ionising Radiation Metrology Laboratory with its national standards for the radiation and radioactive quantities is the primary laboratory of the Portuguese metrology system and is a member of international organisations such as EUROMET and IAEA-WHO (SSDL Network);
- the cytogenetic analysis laboratory is recognised by the IAEA as competent in the area of radiation biological dosimetry.

In general the analytical quality and its control is well known of DPRSN researchers and they have an active participation in international organisations (Carvalho et al, 1999; Coquery et al , 2000).

3.4 Interviews with the local medical authorities and the medical authorities of the multinational forces

The scientific mission to the Balkans tried to meet with several medical, sanitary and radiological protection authorities in order to obtain information on epidemiological data that might be useful for the evaluation of the civilian population health impact due to depleted uranium and to other radioactive elements.

The Mission did not meet with the medical authorities of Kosovo through lack of time. In a meeting with the German military officers in Prizren, south of Kosovo, we were told that

the United Nations Mission in Kosovo (UNMIK) had requested to the WHO to undertake an epidemiological assessment and a sanitary evaluation of the region, and that such a mission would take place in the next few days. In fact, the mission was carried out from January 22nd to the 31st, 2001 (WHO, 2001).

In BiH, the scientific mission was able to use the Portuguese mission in Sarajevo[3] to organise meetings with the local authorities. In BiH the mission also met with medical officers in charge of the Danish military contingent and of the German NBC Division based at the SFOR's Military Hospital in Rajlovac.

4 RESULTS OF THE SCIENTIFIC MISSION IN THE BALKANS

4.1. Monitoring of external radiation dose rate and surface contamination (instantaneous measurements)

Tables 1 and 2 and Figures 4 and 5 show the places where radiation measurements and sample collection for analysis were taken.

Tables 4 to 13 and Figures 12 to 18 contain measurement results (instantaneous dose rate and surface radioactive particles emission rate) made in the Balkans with portable radiation detectors.

The careful monitoring of facilities used as barracks by military forces (including dormitory, mess-halls, workshops, parades) did not show abnormal values, meaning high values for ionising radiation.

Individual monitoring was made in Kosovo and Bosnia-Herzegovina. At Kosovo special attention was given to military personnel upon return from patrol missions. No radioactive contamination was detected on clothing, hair, hands, boots, cars or other equipment.

The same procedure was carried out in Bosnia-Herzegovina, and negative results were observed for the Portuguese military forces staying at Visoko, Doboj and Zenica (Table 12 and 13).

These measurement results should be compared with measurements carried out in the Lisbon region with the same equipment immediately after the mission returns.

4.2. Monitoring of external radiation. Dose registered with personal thermoluminescent dosemeter (integrated measurements)

Personal dosemeters for members of the scientific mission, for journalists, military personnel and police officers were all analysed, as well as control dosemeters. Dosemeters of a "reference group" of military personnel serving in the Lisbon region and worn during February were also analysed.

All the dosemeter results are presented in Figures 19 and 20. In Figure 20 the detection limit of 0.03 mSv is shown by the dotted line (Hirning, 1992). The recording level for a monthly control period (0.20 mSv) is also presented. Doses above this level are registered in the worker's dose record. Below this level the dosemeter reading does not statistically differ from the natural background, and 0.00 mSv is registered. Measured values are so low that it was decided not to introduce correction or normalisation factors for the different periods the dosemeters were used. It can be seen that military personnel, police officers and members of the scientific mission show dose values identical to those registered by control dosemeters (Figure 19). The military personnel in Lisbon using the same type of dosemeter received external radiation doses comparable to those received by the military personnel in the Balkans (Figure 20).

For comparative purposes, individual dose values for DPRSN workers using the same type of dosemeter in the usual working places at ITN during last December, are shown, confirming that external radiation doses in the Balkans are not higher than doses registered in Portugal. It should be noticed that this type of dosemeter is adequate for X and gamma radiation but not for alpha nor beta radiation.

4.3. Radioactivity analysis in food, soils, water and aerosols

4.3.1.Food

Gamma spectrometry results for food samples gathered in Kosovo and Bosnia are shown in Tables 15 and 16. Only radionuclides of major interest are mentioned, but some other radionuclides of natural series could also be detected. The concentrations measured should be compared with samples of similar food products produced in Portugal and analysed by DPRSN (Table 17).

In general, the radionuclides detected in the Balkans foodstuffs are those from natural series. Concentrations are usually low, often even very low (Table 15 and 16). Nevertheless in some samples measurable concentrations of radionuclides such as ^{234}Th, ^{234}Pa and ^{226}Ra were found. Amongst the common natural radionuclides, potassium-40 (^{40}K) has high concentrations. This radioactive isotope of potassium, existing since the earth's formation, shows a small abundance (0.01% of total potassium). An adult human body, containing 2g of potassium per kg of weight, also contains ^{40}K, contributing to an average mean activity of 60 Bq/kg in human tissues (UNSCEAR, 1982).

Special attention was paid to the possible presence of gamma-emitting radionuclides of artificial origin, such as ^{241}Am, ^{60}Co , ^{65}Zn, ^{192}Ir. Their presence would have originated in radioactive contamination due to human activity, meaning either in the ammunitions or in

[3] Mission of Portugal in Sarajevo, Cobanija 12, 71000 Sarajevo.

radioactive materials kept in facilities that may have been demolished by bombing. None of those radionuclides was detected in the samples (Figure 21).

The only gamma-emitting radionuclide of artificial origin detected in the samples was Cesium-137 (^{137}Cs). Traces of this radionuclide, sometimes quantifiable, were detected in some food samples, always in very low activity. It should be noticed that ^{137}Cs is also present in samples collected in Portugal (Table 17). Nowadays this radionuclide is present on the planet in every latitude, mostly as a result of radioactive contamination due to nuclear weapon tests in the atmosphere during the 50s and 60s (Eisenbud and Gesell, 1997) and to the nuclear accident of Chernobyl in 1986 (UNSCEAR, 2000).

The results for uranium and related isotopes in food samples are shown in Tables 18 and 19 and Figure 21. One may see that concentrations and isotopic ratios are normal, in general.

4.3.2. Soils

Tables 20 and 21 show gamma spectrometry measurements in soil samples. Results show that no high values for uranium occurred for samples collected in Kosovo and Bosnia-Herzegovina. For comparative purposes several types of soils collected in Portugal and analysed by the DPRSN during 2000 and 2001 are shown in Table 22.

It should be noticed that concentrations of natural origin radionuclides are higher in soils than in foodstuff, as expected.

The detected gamma emitter ^{137}Cs of artificial origin also shows higher concentrations in soils. Besides, ^{137}Cs concentrations in Balkans soils are generally higher than in Portuguese ones, due to a much larger radioactive atmospheric deposition from the Chernobyl nuclear accident. It should be noted that the Iberian peninsula was scarcely affected by the deposition of radioactive dust from Chernobyl.

In Kosovo and Bosnia soils, uranium isotopes as well as total uranium determinations were made, using alpha spectrometry. Results are shown in tables 23 and 24. These also include some results referring to plutonium from atmospheric deposition.

Analysis of soils from the Balkans show in general low uranium concentrations, meaning 2-3 mg/kg. This content is similar to Ribatejo soils and to the average contents of the earth's crust (see page 11). The isotopic ratios of uranium in most samples from the Balkans are also normal (Tables 23 and 24). Exceptions are Station 6, Djakovica where depleted uranium contamination was confirmed and Station 43, a bomb site near the Lake Radonic dam. At Station 43, the soil sample was collected inside the hole made by the impact of depleted uranium ammunition. This displayed radioactive contamination and modified uranium isotopic ratios as could have been expected (see Figure 22).

Nevertheless, soil samples collected a few meters away from the site of impact or on the banks of the lake do not contain depleted uranium traces, a fact which points to very localised contamination, practically restricted to the impact site.

It should be noticed that at Station 29, Prlina (Kosovo), corresponding to a former bus station where bombed wreckage could be found, the soils do not contain depleted uranium residues. Local monitoring by the mission did not indicate radioactive uranium contamination in the remains of tanks and other vehicle wreckage.

4.3.3. Water

Water samples were analysed by alpha spectrometry. The results for Kosovo and Bosnia are presented on Tables 25 and 26, and for comparitive purposes, results of analysis of Portuguese waters are shown on Table 27.

Total uranium concentration in Kosovo water (0.20 to 0.76 $\mu g\ L^{-1}$) is comparable to average concentrations in Bosnia waters (0.06 to 1.20 $\mu g\ L^{-1}$) and Portuguese waters (0.07 to 2.55 $\mu g\ L^{-1}$). All samples were analysed without prior filtration to remove small particles, that is, analyses were performed on samples that might be ingested. Had filtration been done, the concentration interval would be reduced as variation is partially due to the amount of suspended particles.

In no case is the uranium concentration high or did the isotopic ratio $^{235}U/^{238}U$ suggest contamination by depleted uranium.

Figure 23 includes alpha spectrogram of two of these samples. The isotopic ratios $^{234}U/^{238}U$ on these different spectra show that the water in Klina is from a deep water supply, but public water has a surface origin (lake or river). This method would also be sensitive to isotopic imbalance or contamination due to depleted uranium.

4.3.4. Aerosols

Table 28 shows the results of aerosol filters analysed by gamma spectrometry. Beryllium-7 and lead-210 are typical radionuclides present in atmospheric samples. Uranium-236, plutonium-237 or americium-241, which could indicate atmospheric particle contamination by transuranium elements due to uranium reprocessing, were not present. One of the filters showed traces of ^{137}Cs, corresponding to soil particle re-suspension.

The same filters were analysed by alpha spectrometry in order to determine the concentrations of uranium isotopes (Table 29). All results are consistent with natural uranium, and today no aerosols of depleted uranium were found. Uranium concentrations vary from place to place, depending upon soil dust in the air. Results of aerosol samples may be compared with the same kind of samples collected in Portugal (Table 30).

4.4 Urine samples analysis by alpha spectrometry

Urine samples from military personnel and some civilians that have been or still are in the Balkans were analysed by alpha spectrometry (Tables 31 to 34). A comparison was made with samples of individuals who were not in the Balkans (Table 35). Results, in ng L^{-1} are comparable among groups. It is not possible to detect significant differences in uranium concentration in urinary excretion of individuals who were in Kosovo, Bosnia or Portugal. Besides, all the samples show a normal isotopic ratio $^{235}U/\ ^{238}U$ not indicating internal contamination with depleted uranium, with the possible exception of a civilian from Kosovo (see Table 31).

Uranium concentration values in urinary excretion of Portuguese nationals who were never in the Balkans (Table 35) suggest a broad interval, 34 to 154 ng L^{-1}. The average value for this small group is 95 ng L^{-1}. We can also provisionally admit that all individuals analysed including those that have been in the Balkans have normal contents of uranium in urinary excretion (Tables 31 to 35), and so the general average would be 75 ng L^{-1}. Individual values are spread between a minimum 7 ng L^{-1} and maximum 682 ng L^{-1}.

Average interim value of uranium in urine, 95 or even 75 ng L^{-1} is relatively high compared to other countries. For instance, studies relating to the United States population point to concentrations about 11 ng L^{-1} and 22 ng L^{-1} depending upon the studies (Ting *et al*., 1999; Hooper *et al*, 1999). As no study of this kind has been made for the Portuguese population we have no data on reference values of our population. A larger sample of the Portuguese population is in preparation and we shall soon be able to indicate a more representative value.

Notwithstanding the lack of a good reference value, three pieces of evidences are to be pointed out. First: there are no huge differences between the various groups surveyed (Tables 31 to 35). Second: isotopic ratios $^{235}U/^{238}U$ in samples show just one possible abnormal value, in a Kosovo civilian (Table 31). Third: American military personnel wounded in the Gulf war by depleted uranium ammunitions and containing shrapnel in their bodies, display concentrations in urinary excretion corresponding to 10-18 μg L^{-1}, which is a factor 100-1000 times higher than those measured in the Portuguese who were in the Balkans (Hooper *et al*. 1999). It should be pointed out that a group of 33 Gulf war veterans internally contaminated with depleted uranium and followed up medically, 10 years after the injuries show neither leukaemia cases nor kidney malfunctions (Hooper *et al*; Priest, 2001).

4.5 Biologic radiation effects research by cytogenetic methods

In controlled experimental conditions, research was undertaken for chromosome aberrations in peripheral blood samples of 15 military that have been serving in the Balkans. These are the same individuals analysed for uranium and mentioned earlier in Table 34.

Simultaneously as a control, an identical analysis was performed on two military personnel who were not serving abroad (Figure 24).

During blood collection procedures, a confidential and exhaustive inquiry was presented to donors relating to past and present personal and professional history, type of working ambient, life style and food habits, smoking habits, clinical and genetic history.

Results of these individuals are shown in Table 36. For each individual, chromosomal damage found in analysed cells is shown.

From these results, one may conclude there is a 95% probability that radiation dose, equivalent to whole body exposure received by peripheral blood of these individuals did not exceed the detection limit. This suggests that these individuals were not exposed to ionising radiation, with the possible exception of individuals 2 and 9.

Admitting that chromosomal aberrations of dicentric type on individuals 2 and 9 are the result of damage induced by ionising radiation (Table 36), then the damage observed suggests they might have received a 130 mGy of gamma radiation dose or 13 mGy in case of alpha radiation exposure. Meanwhile one of these individuals was specifically analysed for uranium in urinary excretion without indication of internal contamination by this element (Table 34).

The personal inquiry showed that individual 2 (Table 36) was having radiographic examination in the previous month and is now under generic medication, probably influencing the results of the cytogenetic study. It is known that individual 9 (Table 36) presents a very complex clinical (personal and familiar) history before service in the Balkans. This means that the observed dicentric may have a different cause.

In the group selected by military hospitals (Table 34 and 36) three of the individuals currently have health problems and are receiving medical support. None of them had positive results (meaning abnormal values) in uranium in urine analysis and cytogenetic analysis.

4.6 Analysis of ammunition fragments and depleted uranium ammunition impact sites

A fragment of a projectile of 185 g weight was collected by the ITN-DPSR team in BiH.

The alpha spectrometry analysis clearly points to depleted uranium and shows traces of uranium-236. Of the uranium-235 content, 0.20% is typical of depleted uranium. The proportion of uranium-236 is just 2.8×10^{-3} % of uranium mass (Figure 25). Alpha spectrometry analysis did not indicate the presence of plutonium in this ammunition. Gamma spectrometry analysis of this fragment and samples of soils collected from impact sites do not show either fission products or transuranium emitters (Table 20).

Soil and ammunition debris collected from a hole made by a depleted uranium bullet impact at Station 43 (Kosovo), were analysed by Gamma spectrometry (Figure 26).

Protactinium-234m and uranium-235 traces were detectable. The analysis of the same material by alpha spectrometry confirms the hole contamination with depleted uranium (Table 23).

Based on these measurements (and re-assessment made after the Preliminary Report), the conclusion can be drawn that an uranium projectile emits a gamma radiation dose of $0.01 \mu Svh^{-1}$ at 1 meter, and a beta radiation dose of 2 $mSvh^{-1}$ on contact.

It follows from this that gamma radiation exposure is almost insignificant but exposure to beta radiation may be important, with the possibility of dermal blessures induction if the projectile is kept in contact with the skin for long. For instance, using it as a ornament in contact with the skin, the dose equivalent to skin may be of 9 Sv/year. Annual limits for effective dose and equivalent dose to skin are 1 mSv and 50 mSv respectively (EURATOM Directive 96/29 13-5-1996). People should therefore be advised not to wear such war souvenirs.

4.7 Interview with local and multinational forces, medical and sanitary authorities

We had no opportunity to contact Kosovo medical and sanitary authorities.

At Bosnia-Herzegovina we had a meeting with Dr. Mehidin Sirbubalo, Federal Administration Director for Radiological Protection and Safety and Mrs Branca Bartolovic', Federal Inspector of Radiological Safety. This organisation functions under the aegis of the Health Ministry[4].

In his comments, Dr. Mehidin Sirbubalo informed us that BiH authorities were not proceeding to a radiological survey, mostly because the appropriate equipment is not available. Although worried about depleted uranium, they have no epidemiological data allowing for an assessment of its effects on the population health.

The mission members met Dr. Zlatko Rabovic[5], Head Haematologist at the Central Clinic of the University of Sarajevo. He informed the mission about difficulties in the national register of leukaemia and sarcoma occurrences. Among patients of the clinic just one case of leukaemia was verified since 1999.

The mission also met Dr. F. Fulenovic, Director of the Public Health Institute of Sarajevo[6]. He considers that a slight increase in cancer was registered in 1996-1997, but since then occurrences are at the usual level. Statistic shows that the cancer mortality rate is now comparable to European countries.

[4] Ministry of Health, Federal Administration for Radiation Protection and Radiation Safety. Titova 9, Sarajevo.
[5] Dr. Zlatko Rabovic, Heamatologist, Klinica Za Hematologiju, Bolnicka 25, 71000 Sarajevo.
[6] Public Health Institute of the Canton of Sarajevo, 03.rj Za Zastitu I unapredenje Zivotne okoline, Dr. M. Pintola br. 1, Ilidzá 71000 Sarajevo.

At the Oncology Hospital of Sarajevo the mission met Dr. Beslija[7], a radiotherapist. He explained that the occurrence of cancer in Sarajevo is not higher than in Slovenia where there was no war. For the Oncology Hospital doctors, the "Balkans Syndrome" has no meaning.

At Camp Dannervique near Sarajevo, one of the barracks monitored, we were informed by the Colonel–Doctor that some time ago several Danish military personnel presented a pathology typical of poisoning by heavy metals. The blood analysis concluded that this was lead intoxication, caused by lead in the soil of the Camp, an old industrial site which had not been decontaminated. As the blood concentration was high above recommended levels, a reduction of individual service was decided and a periodical control is currently done for this brigade.

At Camp One Carreau, where the SFOR Military Hospital is installed, the mission met the NBC Brigade of German Forces, under the command of Colonel R. Rambouski[8]. Members of this brigade were particularly interested in the comparison of his measurement results with those of the Portuguese Scientific Mission, since both brigades had visited the same places on different days. The conclusion was that dose and contamination measurements were most according.

4.8 Potential Impact in Public Health of other sanitary problems

Although the Portuguese Scientific Mission had just to assess the radiological risk from the use of depleted uranium ammunitions, other sanitary problems were found as potential threats to public health: the industrial complex in Trerza, now abandoned, is heavily contaminated with cadmium, lead and phosphate; rivers and water courses are polluted all over Kosovo, mostly from old car wreckage, and in populated regions sanitary conditions are poor.

In Bosnia-Herzegovina, where there had been better industrial and economical development, toxic products have a poor safety record. At Hrasnica, North of Sarajevo, 50 tons of cyanide and 20 tons of concentrated sodium hydroxide are kept in bad storage conditions.

At BiH, Granica, an old complex was the cause of pollution problems through lead, nickel, lithium and cadmium in the environment.

At Hadzici, South of Sarajevo, the are tons of ammunition in the woods, resulting from bombing of former military ammunition stores. In the hills surrounding Sarajevo, in the road to Pale, mined fields are poorly marked. SFOR provides information about the risk of mines, but tens of thousands of them are still scattered around Sarajevo.

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[7] Institute of Oncology, Clinical Centre University Sarajevo, Bolnicka 25, 71000 Sarajevo.
[8] Armed Forces Scientific Institute for Protection Technologies, NBC Protection, P.O. Box 1142, D-29623 Munster, Germany.

SFOR Commando takes measures to control or minimise industrial risks and war residues risk. But in this domain there is much to be done.

5 RESULTS OF THE SURVEY FOR URANIUM IN SAMPLES COLLECTED AT THE MILITARY HOSPITALS

Since mid January 2001, the DPRSN has analysed 2500 24-hour urine samples, the majority of them as part of the medical survey performed at the military hospitals on persons that were sent to the Balkans on peacekeeping missions.

The samples were sent to ITN-DPRSN for analysis at intervals that depended on collection. 75% of all the samples analysed came from the Hospital Militar Principal (Main Military Hospital), 12% from the Hospital da Força Aérea (Air Force Hospital), 7% from the Hospital da Marinha (Navy Hospital), and 6% were collected by the DPRSN. All the samples sent by the military hospitals were coded with an identification number, so the donors were kept anonymous. The results were returned to the military hospitals for clinical interpretation and registration in the individual's medical file. The military hospitals were asked to collect 250 reference samples, e.g., samples collected at barracks in Portugal from military personnel that had never been in the Balkan. The reference samples are of the utmost importance as they will be used as a comparison, to detect if the military personnel sent to the Balkans were contaminated or not.

The results presented here do not violate either the identity of the donors or the clinical evaluation performed by the medical authorities. They are absolutely necessary for the statistical assessment of "normal" uranium values obtained for the reference group, and the uranium values for each of the groups that have been to the Balkans.

Figures 27 and 28 show the histograms of the uranium activity found in the various groups of individuals. The statistical analysis does not include all the samples analysed (2500), since the information on the mission site of the military is known for 1100 donors only.

The main statistical data on the groups studied are shown in Table 37. From the observation of these results, it can be concluded that no statistically significant differences are detected in the uranium values measured in the group of military and civilian personnel who were in Kosovo, in the group that was in BiH, in the group that was both in Kosovo and in BiH and in the group of individuals that have never left Portugal. There also seems to be no statistically significant differences between the group of military personnel and the group of civilians. It is to be noted that the uranium values measured in the reference group are slightly higher than the values measured in groups that were sent to the Balkans. Although the differences are very small they may reflect the different uranium content ingested from the foodstuff and drinking water in Portugal and in the Balkans.

The results shown and a comparison of the histograms in Figures 27 and 28 are self-explanatory. Individuals that are or have been in the Balkans and were surveyed for the

determination of beta activity in urinary excretion do not seem to be contaminated with uranium.

The results have undergone further studies since these types of studies are rare in Portugal.

From the uranium concentration results measured for the Portuguese population reference group (median of 3.2 net cpm L^{-1}, which corresponds approx. to an uranium concentration of 75 ng L^{-1}), the highest individual value is (10.5 net cpm L^{-1}) which is only 3.3 times higher than the median (Table 37). This corresponds to a concentration of uranium of 248 ng L^{-1} (0.248 μg L^{-1}). The highest concentration value measured by alpha spectrometry was 682 ng L^{-1} (Table 32).

In Portugal there are no statutory limits for uranium in urinary excretion. The results obtained can be compared with the "decision limits" used in the United States when safety procedures in work premises are applied (miners and professionally exposed workers in the uranium industry). These are 0.8 μg L^{-1} for uranium in urine (FEMP, 1997).

This means that the uranium concentrations measured in the samples of Portuguese military and ITPF police (including civilians from Kosovo that were also analysed), are not close to the occupational limits. The value of the median determined for the Portuguese military is 75 ng L^{-1}, which does not exceed 1/10 of the occupational limit.

From all the individuals selected by the military hospitals (supposedly based on medical criteria and not at random), the highest uranium concentration value found was 347 ng L^{-1} (Table 34), which is very low when compared to the limits established in American legislation.

6 URANIUM ANALYSIS IN TISSUE SAMPLES COLLECTED *POST-MORTEM*

The DPRSN was requested to analyse *post-mortem* tissue samples collected during the autopsy of an individual who served in the Balkans and who, according to the death certificate, died of myeloid leukaemia.

The analysis was performed with gamma spectrometry of the samples directly followed by alpha spectrometry. For comparison purposes, samples of equivalent tissues were requested from the Instituto de Medicina Legal de Lisboa. All the samples were delivered by the Instituto de Medicina Legal de Lisboa to the DPRSN according to the legal and ethical procedures which apply. These samples were analysed using the same methodologies and the same equipment as those previously studied. The results are shown in Tables 38 and 39.

From the results obtained it is possible to conclude that there were no artificial radionuclides either in the organ samples of the individual who had been to the Balkans, or in the samples of the reference persons (Table 38). From the alpha spectrometry analysis it

can be inferred that the uranium concentration in the body of the individual who had been to the Balkans showed typical concentration levels, e.g., comparable to the levels measured in the body of the reference persons (Table 39).

From these results it is not possible to establish a connection between the disease that affected this person and the existence of depleted uranium, or any other radionuclide in the body of the deceased person.

7 CONCLUSIONS

The scientific research work presented here made use of a variety of methodologies, different types of equipment and know-how available at the DPRSN. An attempt was made to provide a complete and comprehensive answer to the questions concerning alleged contamination with depleted uranium and the radiological risk to the Portuguese military personnel sent to the Balkans.

While the analysis of the samples collected in the Balkans was taking place and in answer to an invitation from the Minister of Ciência e Tecnologia to the WHO, two members of this organisation visited Portugal. The aim of their visit was to assess the work being made in Portugal and to comment on the results of the WHO mission to Kosovo.

The WHO delegation[9] comprised Mr. P. Rushbrook and Mr. C. Dora and visited ITN-DPRSN on March 5th, 2001. They were able to observe and comment in detail on the work that was being done at the DPRSN. On their report it is stated:

…"We were very impressed by the breadth of the programme of environmental sampling undertaken in the Balkans and the thoroughness of the analytical effort being made in Portugal. The work conducted on alpha spectrometry is particularly useful in order to identify isotopic abundance of uranium and other isotopes. Your detailed results were the first that we had seen that demonstrate clearly the absence of elevated uranium concentrations and radioactivity in environmental samples from Kosovo and Bosnia. We congratulate you and your staff on their hard work and attention to detail."…

These remarks are worth highlighting, since they were made by an external, independent and unimpeachable organisation.

From the large amount of results obtained, produced over the last three months of very hard work, it is possible to reach the following conclusions:

1. The barracks presently in use and used previously by the Portuguese military personnel sent to the Balkans are not contaminated with depleted uranium. They are also not contaminated with any other natural or artificial radioactive element, apart from the natural environmental radioactive background. The natural radioactive background in the Balkans, although not very different from the background observed in Portugal, is slightly lower due to the different geology of the region.
2. The vehicles, garments and other equipment used by the Portuguese military personnel in Kosovo and in Bosnia were thoroughly monitored. No traces of radioactive contamination were detected upon the return of patrols and missions performed by the military in the areas within their field of responsibility.

[9] World Health Organisation, European Centre for Environment and Health, WHO Rome Division.

3. The analysis of the soil, aerosols, foodstuff and water samples collected in Kosovo suggest there is no widespread radioactive contamination of the environment. In the areas monitored, which correspond to most of the Kosovo territory, the Portuguese are not in contact with radionuclides of artificial origin. Particularly, they are not in contact with depleted uranium that would represent an irradiation or contamination health hazard. In Bosnia-Herzegovina nearly half of the country was monitored by the scientific team and similar conclusions could be reached, i.e., there is no generalised radioactive contamination of the environment. This was concluded by the analysis performed both *in situ* and in the laboratory.
4. The sites that were bombed with ammunitions containing depleted uranium are an exception. In these places, traces of depleted uranium could be detected, although the contamination and the radiation increase were restricted to the ammunition impact site. In the surrounding environment, including the soil and water collected at very short distance from these sites, the uranium concentration detected was not higher than the natural radioactive background. It seams feasible to admit that other bombed sites, not visited by the mission, present a similar situation.
5. The sole artificial radioactive element generally present in the soil samples collected in the Balkans was Cesium-137, caused by nuclear bomb testing and from the Chernobyl nuclear accident. It is to be noted that ^{137}Cs is present in every latitude on the planet. Concentrations of ^{137}Cs in the Balkans soil samples are slightly higher than the ones observed in samples of soils from Portugal, since the radioactive dust from Chernobyl deposited in that area was more intense. Concentrations of ^{137}Cs in aerosols and foodstuff from the Balkans are also not significantly higher. As a consequence, the concentration of ^{137}Cs measured suggests there is no increased radiological health hazard due to this element.
6. The depleted uranium ammunitions used in the Balkans by the NATO forces were contaminated with ^{236}U. In the fragment analysed the amount of ^{236}U represents 2.8×10^{-3} % of the total uranium. Since no traces of plutonium, americium and fission products could be found, the contamination might have occurred in the manufacturing process and was probably not due to the use of recycled uranium.
7. In Kosovo, nearly 31000 ammunitions of this type are thought to have been used, and nearly 5000 in Bosnia. Many of them might not have reached the targets and have been lost, penetrating in the surrounding soil to various depths. It is known that some of these uranium projectiles have been found by the local

population. Keeping one of these uranium metal "penetrators" for a long time (in a pocket, as a decorative item around one's neck, at home, etc.), may give rise to significant irradiation. For this reason, it is of the utmost importance to recommend the local population not to keep these objects and to notify their existence to the multinational forces. Portuguese military personnel should also receive instructions on this matter and be advised not to keep these objects as "souvenirs from the Balkans".

8. From the meetings with the Radiological Protection authorities of Bosnia-Herzegovina and with the medical authorities of the Sarajevo district, it can be concluded that there are no recent data on environmental radiation. Local hospital statistics on the incidence of malignant diseases do not show a rise in leukaemia or malignant tumours in the local population. However, the medical doctors interviewed seem to agree that there is a gap in the health statistics during the war period and that the comparison of the present incidence rates of malignant diseases with pre-war statistics are greatly affected by the displacement and segregation of the local populations and due to the lack of registration during the war years. However, the experience and registers of the Hospital of Oncology show that the incidence of solid tumours in the Sarajevo district is lower than in Slovenia, a country that was not at war. The experience of other medical doctors, experts on leukaemia cases, illustrates that there is no leukaemia increment observed in BiH in the post-war period, that is, since 1996. The statements of the local authorities should be carefully considered, at least until more complete and thorough epidemiological data can be produced.
9. The analysis of the foodstuffs available at the local markets in Kosovo and in BiH, and of the foodstuffs delivered by NATO to the Portuguese military personnel suggest they are not a contamination pathway for the military personnel, police forces and civilians. No other radioactive elements were found in the foodstuff that might represent a health hazard.
10. The internal radiation doses due to the ingestion of the foodstuff available in the Balkans does not represent a higher radiological risk compared to the ingestion of foodstuff produced in Portugal or delivered by the NATO logistic supply network. These results do not allow for conclusions on the risk of other non-radioactive contaminants (chemical, bacteriological or other) that may exist in the foodstuff and that were not investigated by this mission.
11. The analysis of the uranium isotopes in the urine samples of military personnel sent to Kosovo and to BiH in January 2001 shows that the total uranium concentration and the uranium isotopic composition is comparable to the values

measured for the Portuguese population. In the groups of military personnel investigated no traces of contamination with depleted uranium could be found.

12. The survey performed by the military hospitals on the Portuguese military personnel who served in the Balkans yielded approx. 2500 urine samples. All the samples were analysed, meaning that almost half of the Portuguese who were in the Balkans have already been analysed. The results do not show any statistically significant difference amongst the groups that served in Kosovo, in Bosnia and in the reference groups (both military and civilian groups that had never been to the Balkans). The results suggest that the Portuguese military personnel have not been in contact with depleted uranium. Taking into consideration that the Portuguese in the Balkans seldom, or never, move alone, the probability of having contaminated staff now seems very low.
13. Cytogenetic analysis by counting the occurrence of dicentric and other chromosomal aberrations was performed on several Balkan veterans, selected by the military hospitals. In the majority of cases, the results show normal values, identical to the results of reference individuals. The results suggest that the group of military personnel analysed was not exposed to significantly high doses of ionising radiation. The results of urine analysis of the same individuals show low uranium concentration values. There seems to be an agreement between the results obtained by biological dosimetry and by urine analysis.
14. The uranium concentration in the urine of three individuals that served in the Balkans and are now ill and under medical surveillance is not abnormally high. The results suggest that these individuals are not internally contaminated with uranium. The cytogenetic analysis of the same three individuals suggests that they were not exposed to any ionising radiation, either from internal or from external sources which might have caused the disease observed (negative result). Two other individuals, who did not show any clinical symptoms of illness, presented chromosomal aberrations of the type that could be attributable to ionising radiation exposure (positive result) (Table 36, numbers 2 and 9). However, inspecting carefully these cases, the results for person n. 2 could be due to general medication and radiographic examinations he has endured in the previous month. Person n. 9 also shows very complex individual and family clinical records, which suggests a different cause for the dicentrics observed.
15. The uranium concentration and the concentration of other radionuclides in the *post-mortem* analysis of tissue samples of a person that served in the Balkans and later died of myeloid leukaemia, were not higher than the normal concentration values measured in individuals who had not been to the Balkans.

In conclusion, based on all the samples analysed and on the information reported and discussed herein, there is no generalised environmental contamination with depleted uranium either in Kosovo, or in Bosnia-Herzegovina. The Portuguese military personnel and police forces that served in the Balkans are also not contaminated with uranium. The specialist analysis requested from the DPRSN on the samples of one sick patient did not reveal the existence of contamination with depleted uranium. In the case of the deceased person, the *post-mortem* analysis of internal organs showed that he was not internally contaminated with uranium or with any other artificial radionuclide.

All the evidence collected in the course of this work suggests that there is a solid basis for the following statement: that <u>there is no cause-effect relationship</u> between the exposure to depleted uranium and the illnesses and deaths observed in the Portuguese military personnel who served in the Balkans.

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9 FIGURES

FIGURES

1. Scientific Mission to Kosovo.

2. Portable equipment used by scientific team.

3. Soil sampling (Kosovo).

4. Radioactivity monitoring with an alpha probe (Kosovo).

5. Monitoring of a bombed site: former Serbian barracks, Djakovica (Kosovo).

6. Monitoring of a bombed site: former bus station, Prlina (Kosovo).

Figure 1. – The Portuguese Scientific Mission to the Balkans. Field work (photos 1 to 6).

7. Monitoring at Volujac mine site (Kosovo).

8. Aerosol sampling (Kosovo).

9. Fragments of ammunitions containing depleted uranium (BiH).

10. Fragments of ammunitions containing depleted uranium.

11. Monitoring of bombed site: hills surrounding Sarajevo (BiH).

12. Anti-truck mines and ammunition from bombed arsenals (BiH).

Figure 2. – The Portuguese Scientific Mission to the Balkans. Field work (photos 7 to 12).

13. Impact sites of 30 mm ammunitions. Lake Radonic (Kosovo).

14. Collecting fragments of depleted uranium ammunitions. Lake Radonic (Kosovo).

15. Monitoring of military personnel. Klina (Kosovo).

16. Monitoring of military personnel and vehicles at Doboj (BiH).

17. Monitoring of wreckage (destroyed tank). Prlina (Kosovo).

18. Monitoring of wreckage (destroyed tank). Prlina (Kosovo).

Figure 3. – The Portuguese Scientific Mission to the Balkans. Field work (photos 13 to 18).

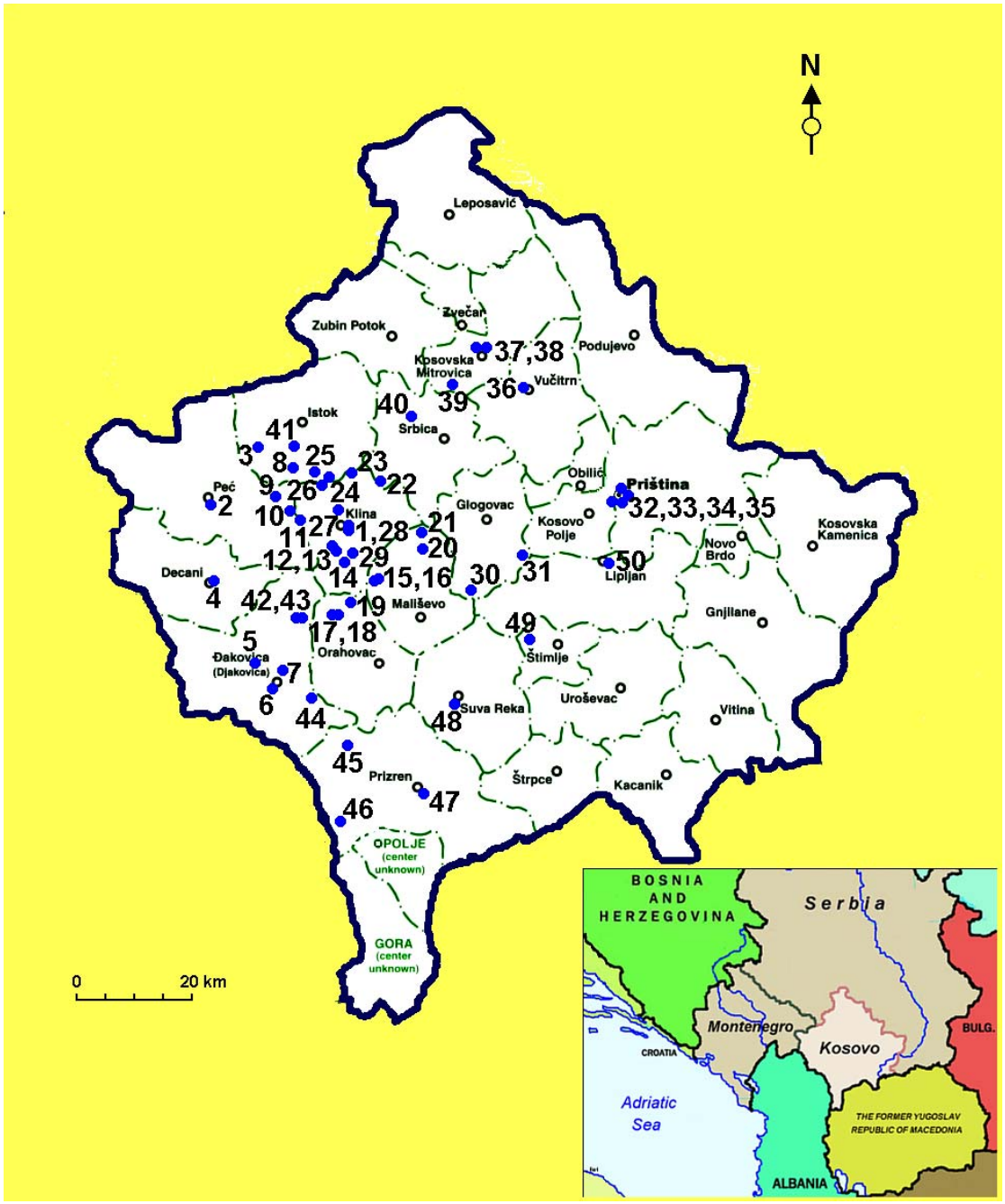


Figure 4 – Kosovo. Identification of sampling sites.

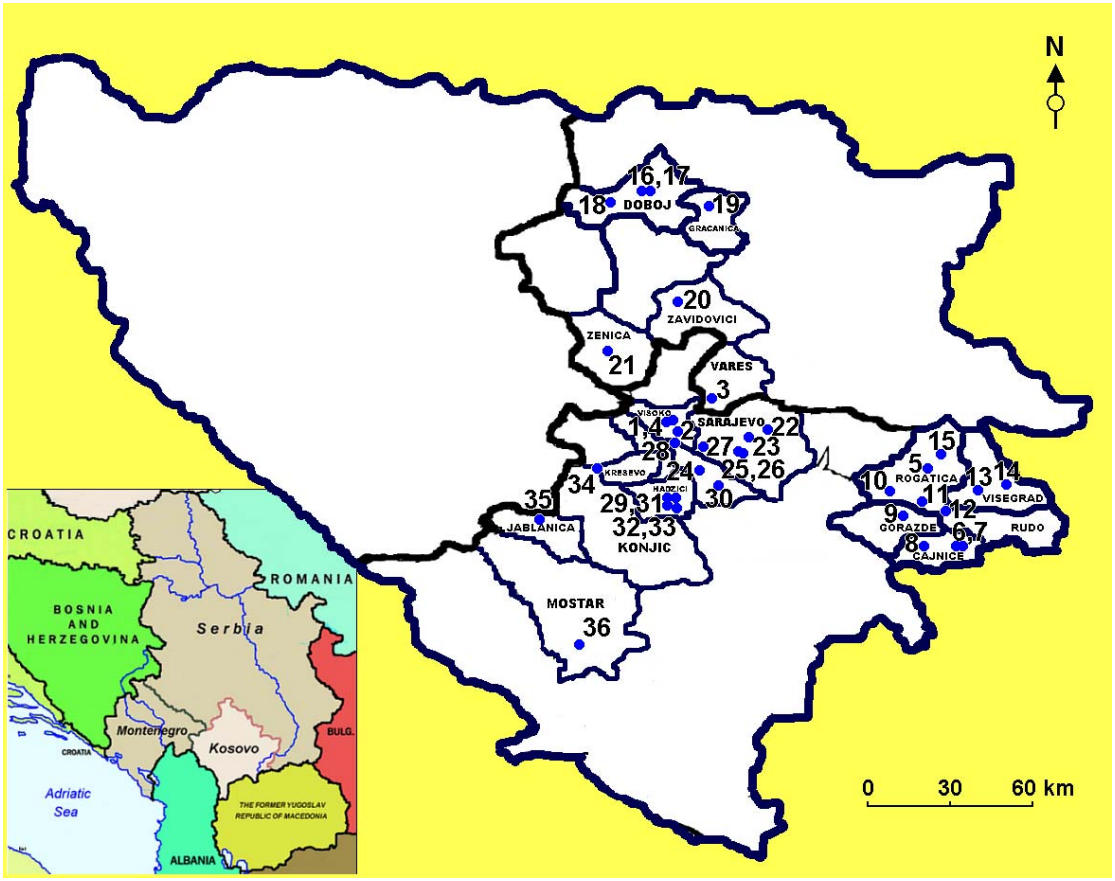
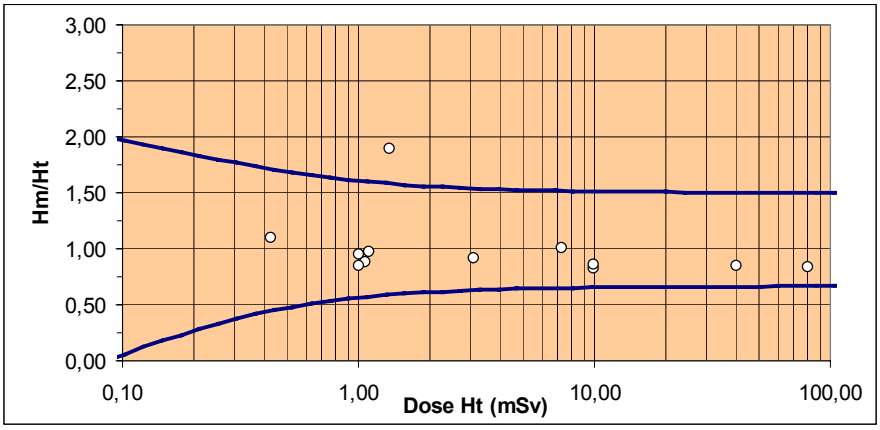


Figure 5 – Bosnia-Herzegovina. Identification of sampling sites.

A



B

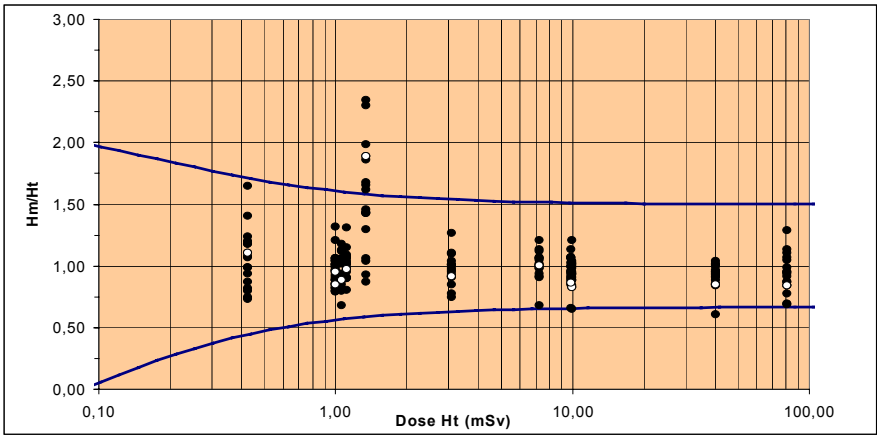


Figure 6 - Results obtained by the DPRSN in the intercomparison of personal dosemeters of external radiation used in the countries of the European Union and Switzerland (Bordy et al., 2000), organised by EURADOS-European Radiation Dosimetry Group in 1998-99. The symbols represent the results and the lines in black represent the lines of maximum and minimum admitted uncertainty. The dosemeters were irradiated in photons beams covering a wide energy and dose range (0.40 to 80 mSv) at the Physicalish-Technische Bundesanstalt (Germany), at the Österreiches Forshungszentrum Seibersdorf (Austria) and at the National Radiological Protection Board (United Kingdom).

A – Results obtained by the DPRSN in the Intercomparison of personal dosemeters of external radiation used in the countries of the European Union and Switzerland.

B – Results of all the laboratories participants to the Intercomparison: ○ - results of the DPRSN, ● - results of the other laboratories

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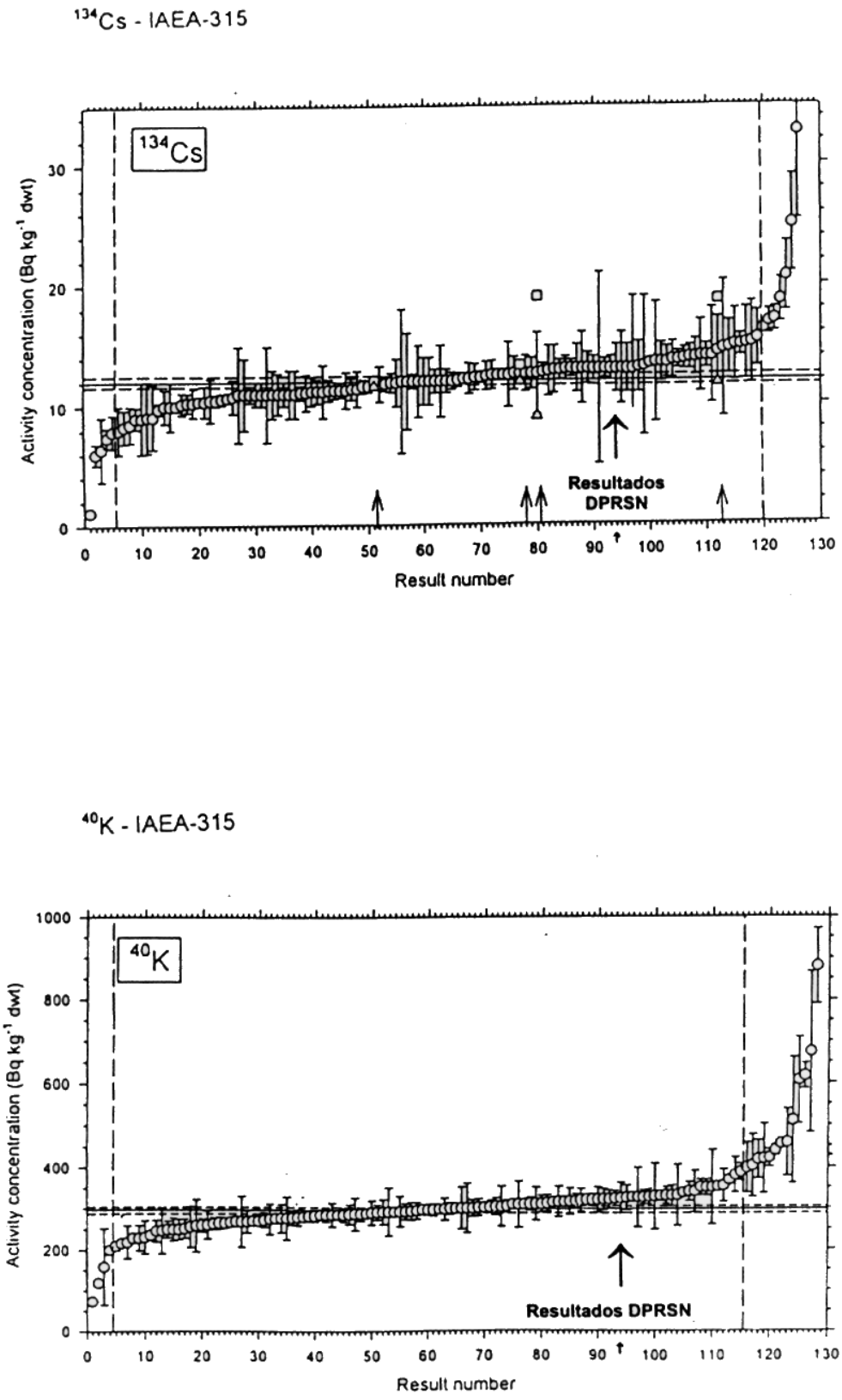


Figure 7 – Results of an intercomparison exercise organized by the International Agency of Atomic Energy. Determination of Cesium-137 and Potassium-40 by gamma spectrometry on soil sample, IAEA-315 (Ballestra *et al.*, 1997).

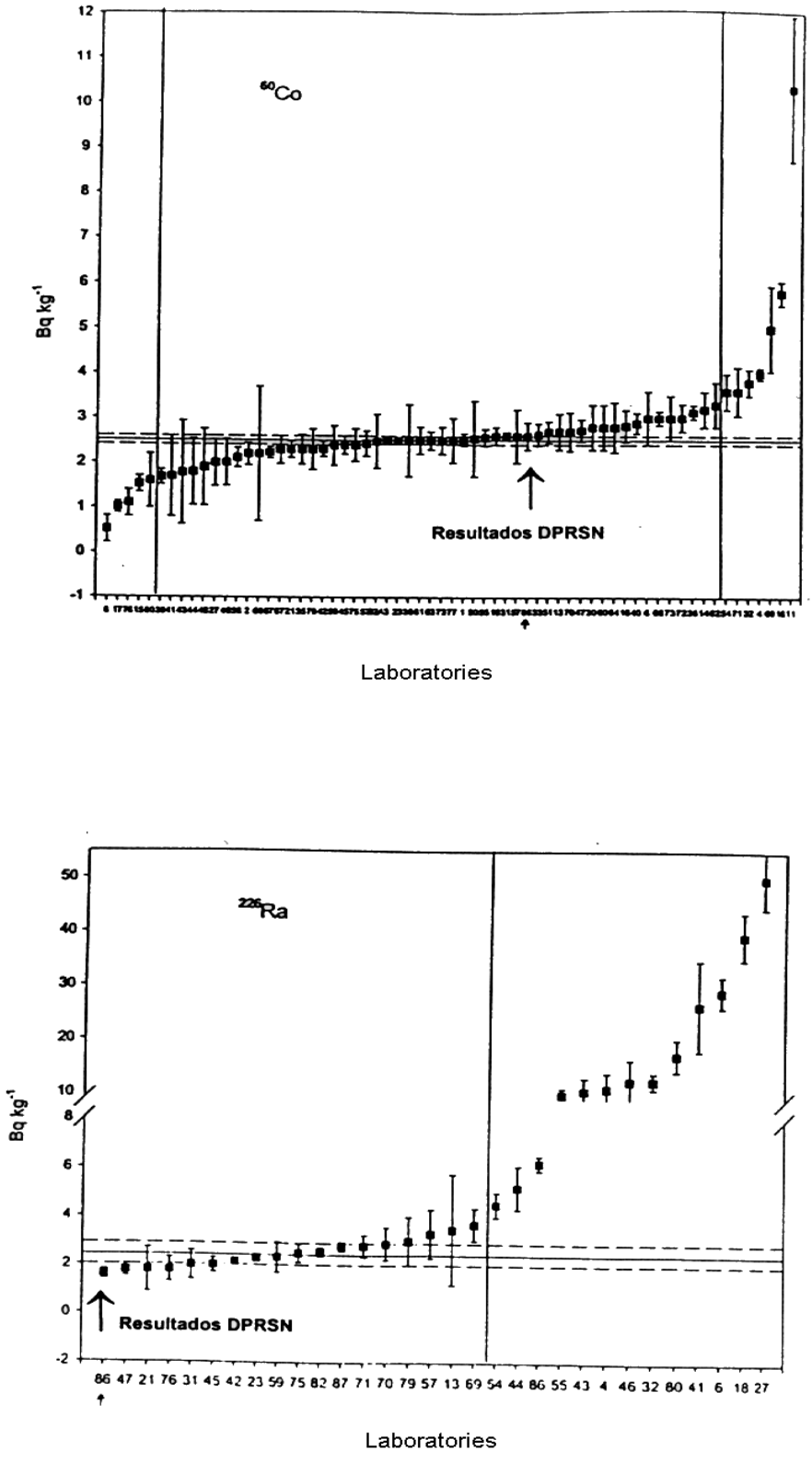


Figure 8 – Results of an intercomparison exercise organized by the International Agency of Atomic Energy. Determination of Cobalt-60 and Radium-226 by gamma spectrometry on a marine sediment sample, IAEA-384 (Povinec and Pham, 2000).

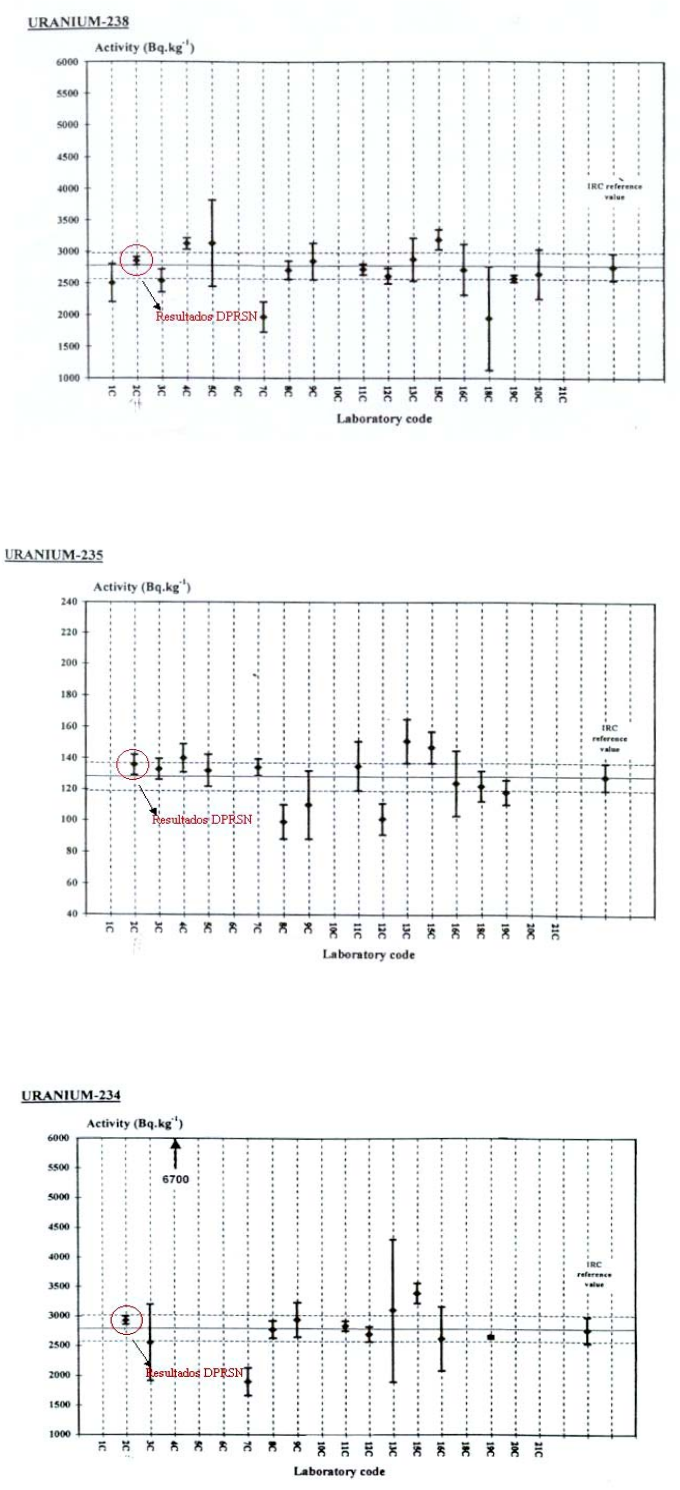


Figure 9 – Results of an intercomparison exercise organized by the World Health Organization. Uranium determination in lacustrine sediment, SR300 (WHO, 1999).

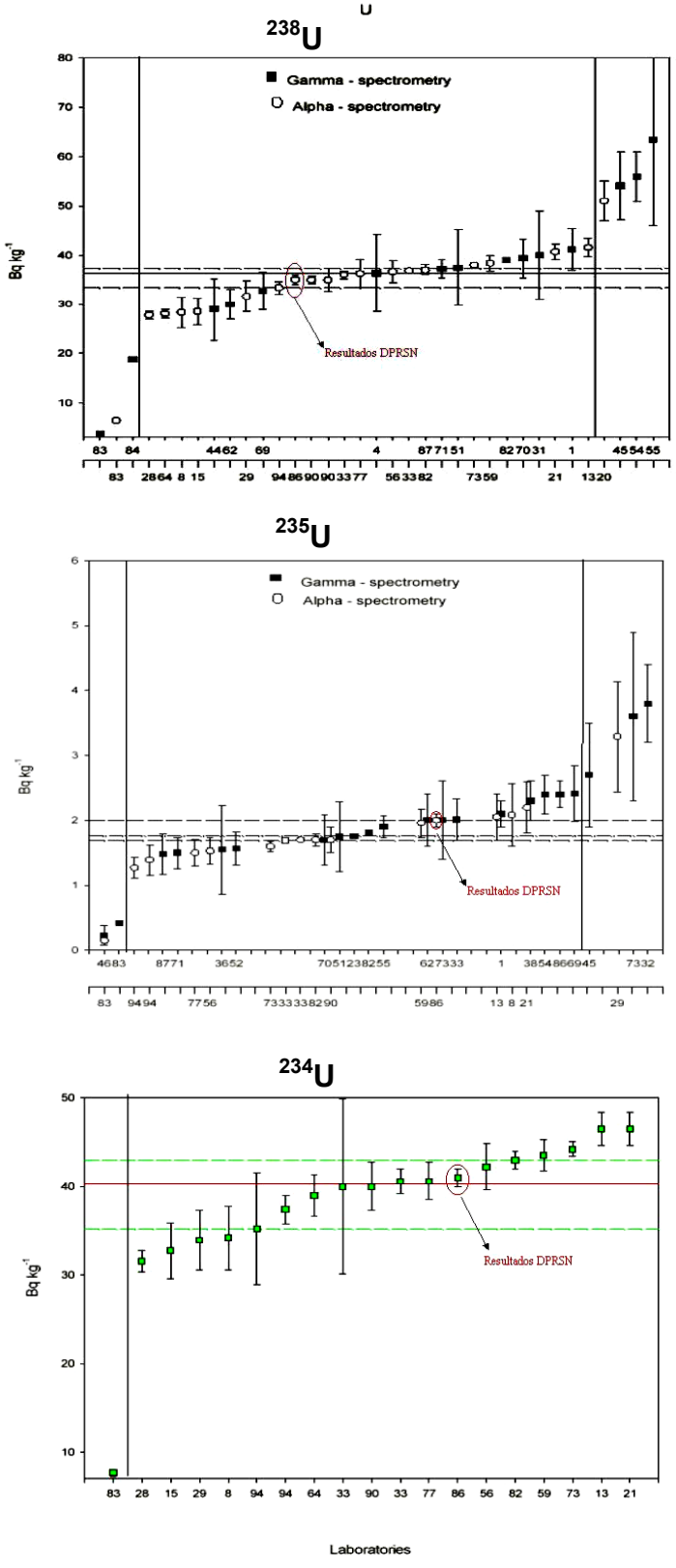


Figure 10 – Results of an intercomparison exercise organized by the International Agency of Atomic Energy. uranium isotopes determination in marine sediment sample, IAEA-384 (Povinec and Pham, 2000).

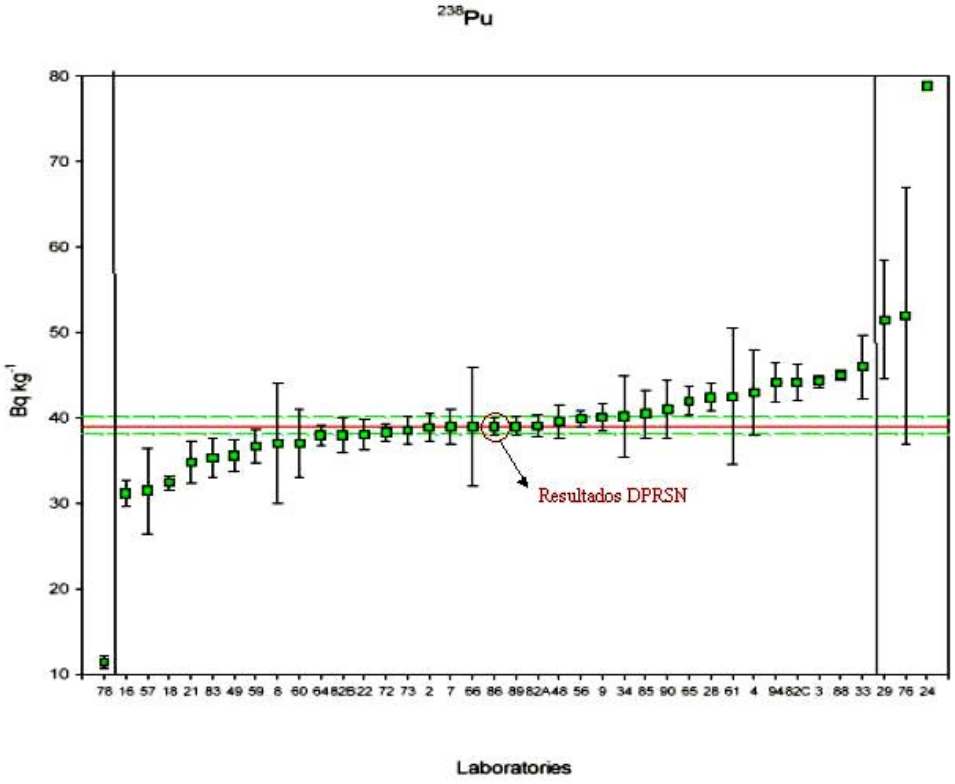


Figure 11 – Results of an intercomparison exercise organized by the International Agency of Atomic Energy. Determination of Plutonium-238 in marine sediment sample, IAEA-384 (Povinec and Pham, 2000).

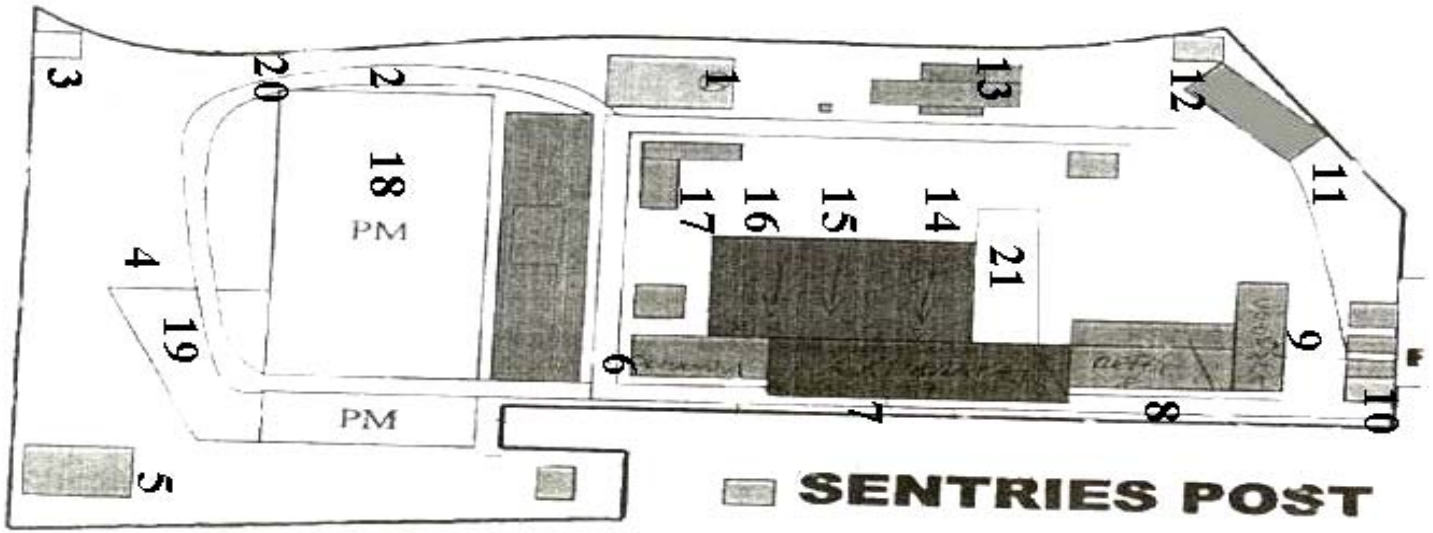


Figure 12 – D.Afonso Henriques barracks, Klina (Kosovo). The numbers are the measuring points.

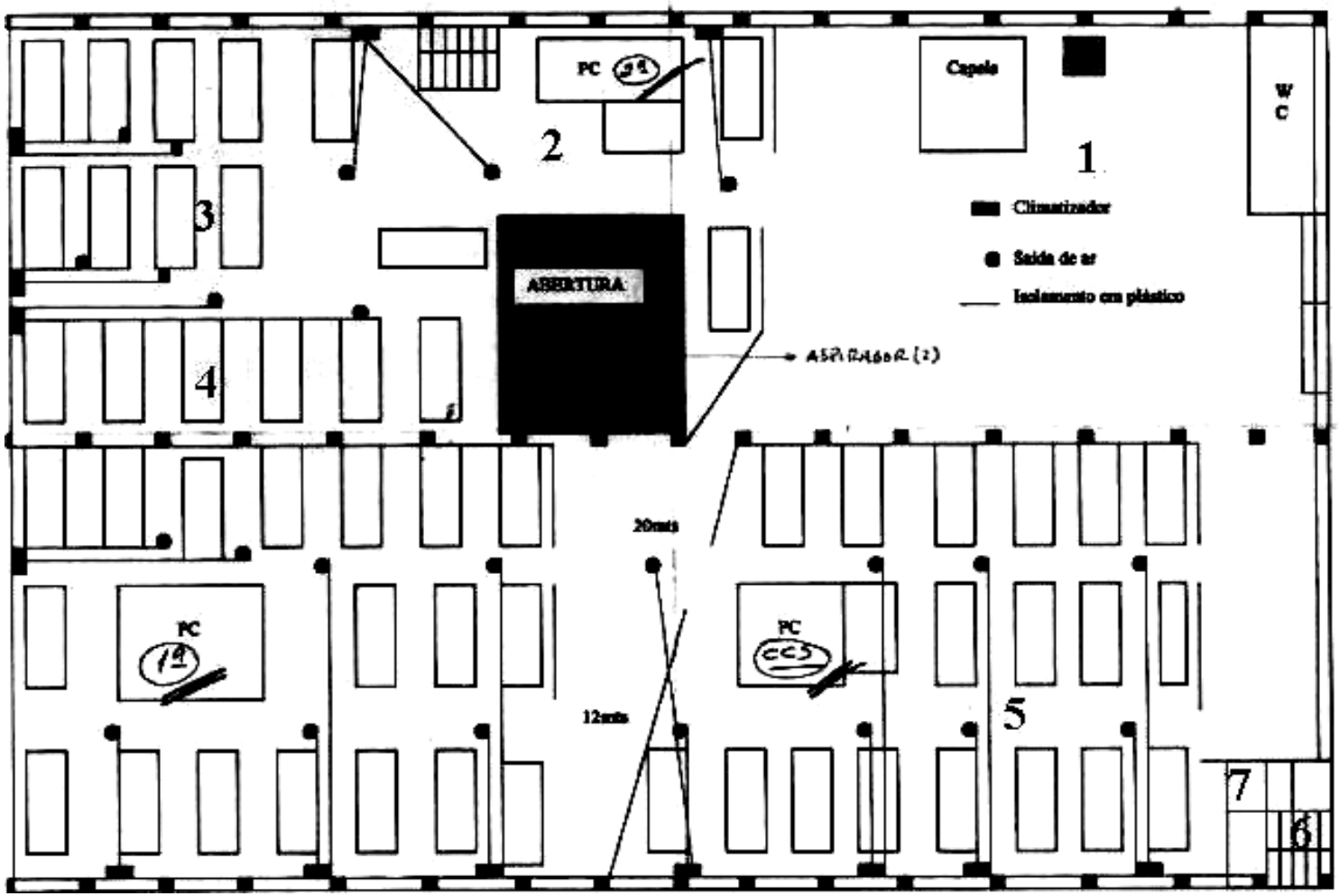


Figure 13 – Plan of main building, Camp Visoko, Bosnia-Herzegovina – upper level (lodgings). The numbers are the measuring points.

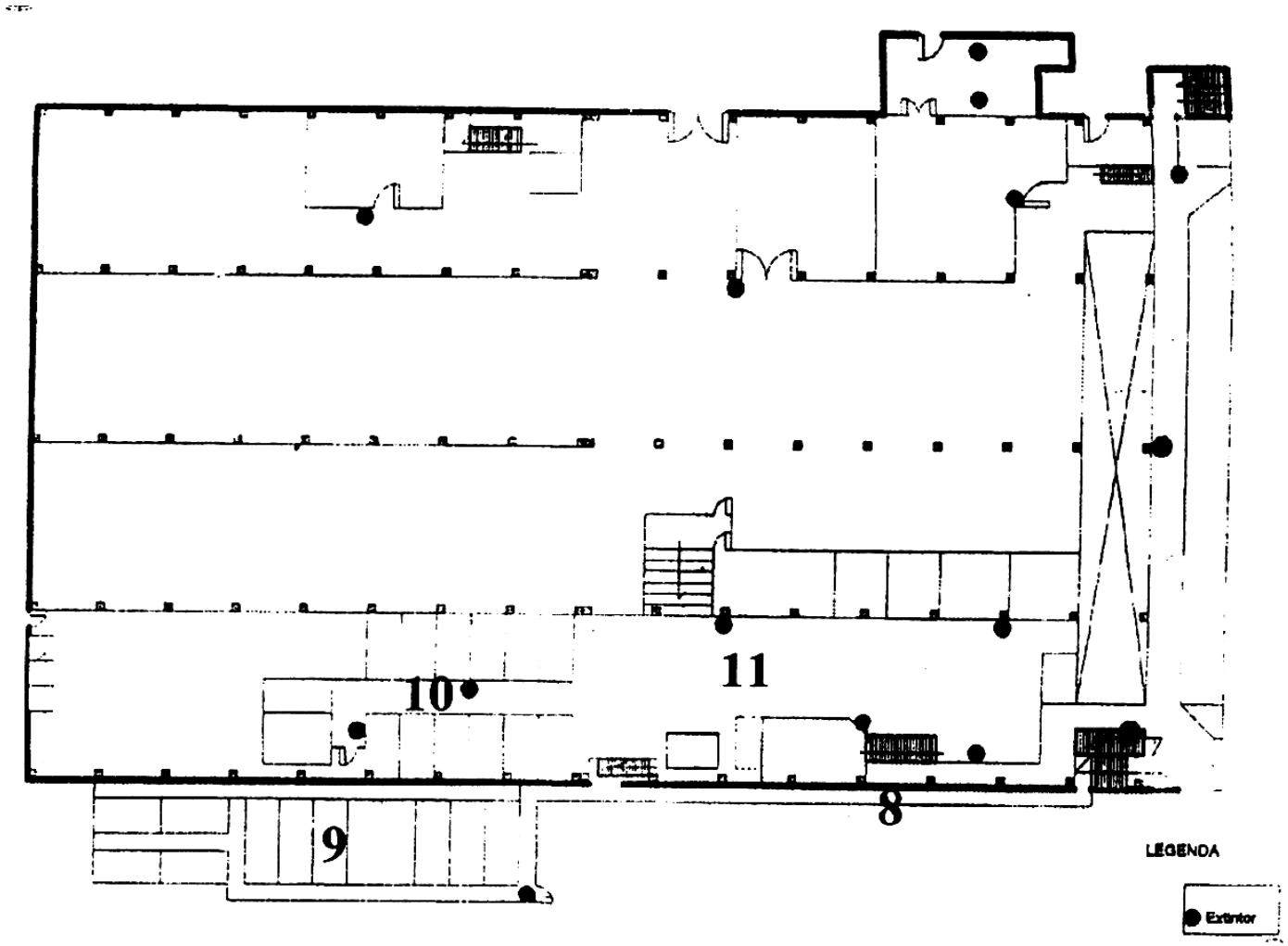


Figure 14 – Plan of main building, Camp Visoko, Bosnia-Herzegovina – upper level. The numbers are the measuring points.

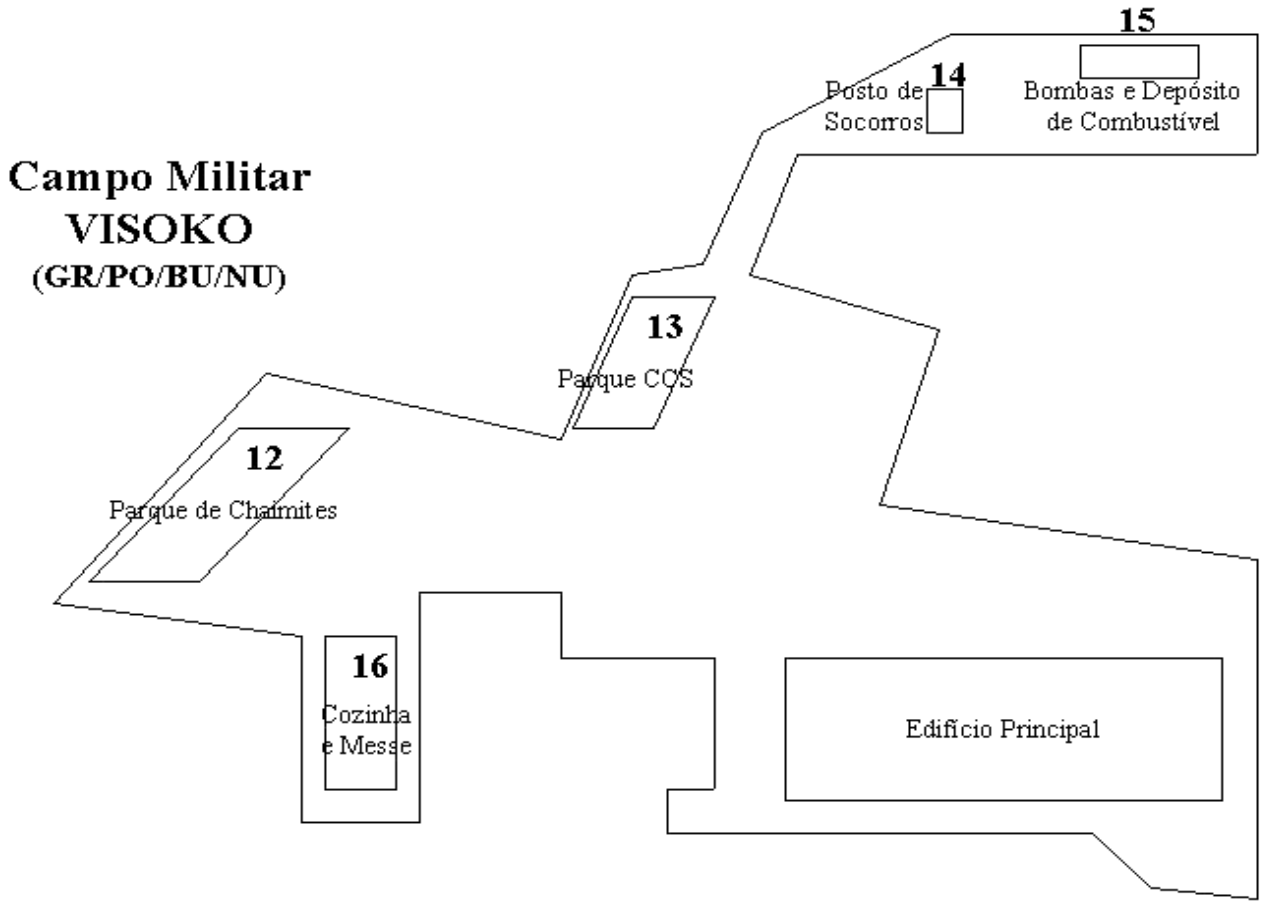


Figure 15 – Camp Visoko, Bosnia-Herzegovina. The numbers are the measuring points.

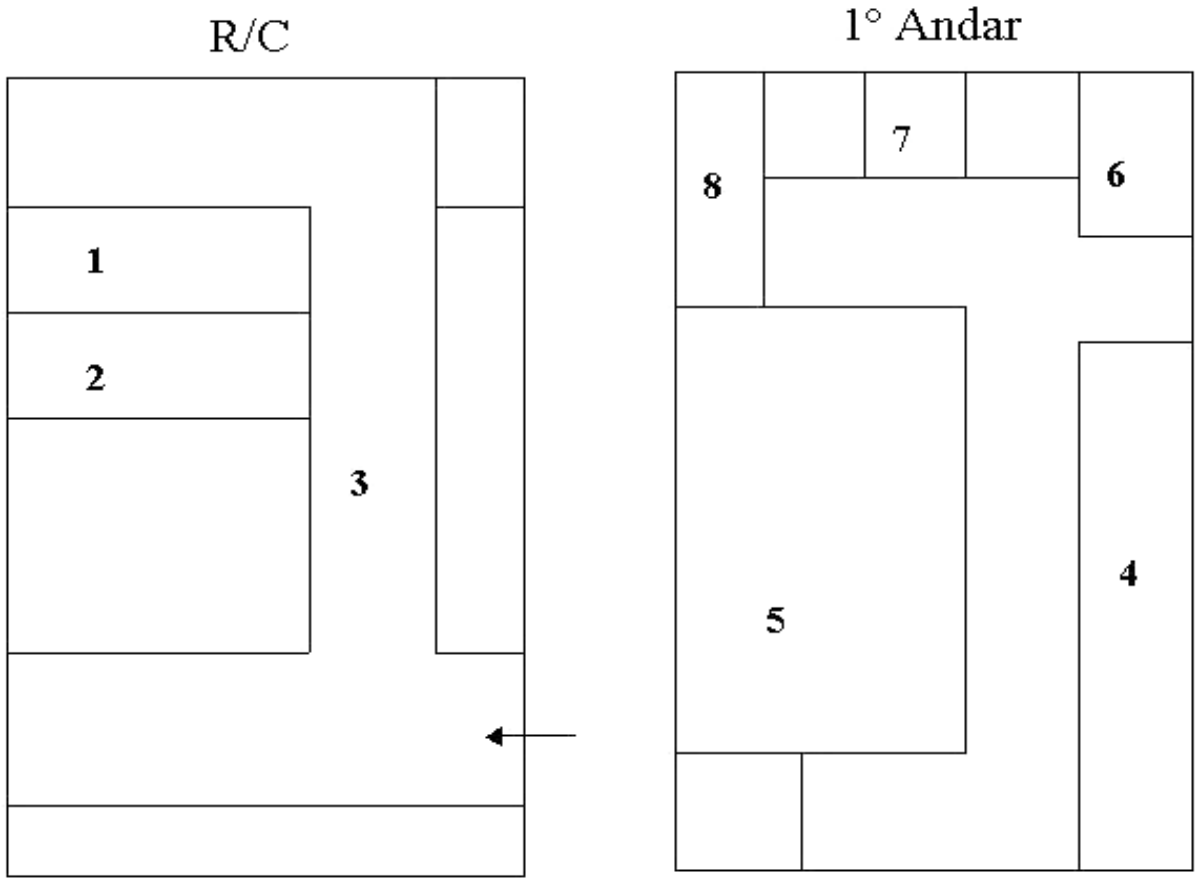


Figure 16 – Plan of old Portuguese barracks, Vitkovice, Bosnia-Herzegovina. The numbers are the measuring points.

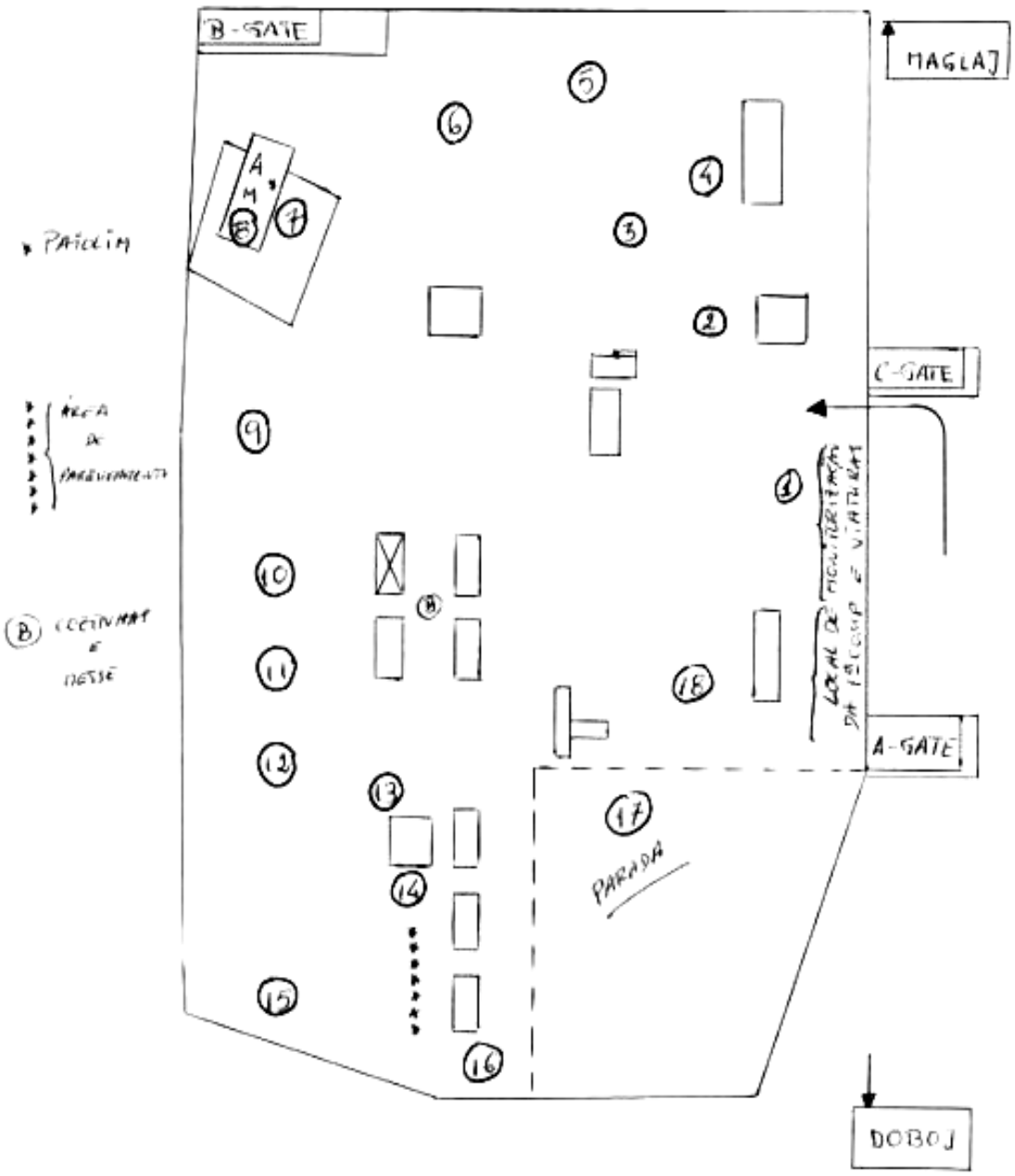


Figure 17 – Plan of Camp Dannevirke, Doboj, Bósnia Herzegovina. The numbers are the measuring points.

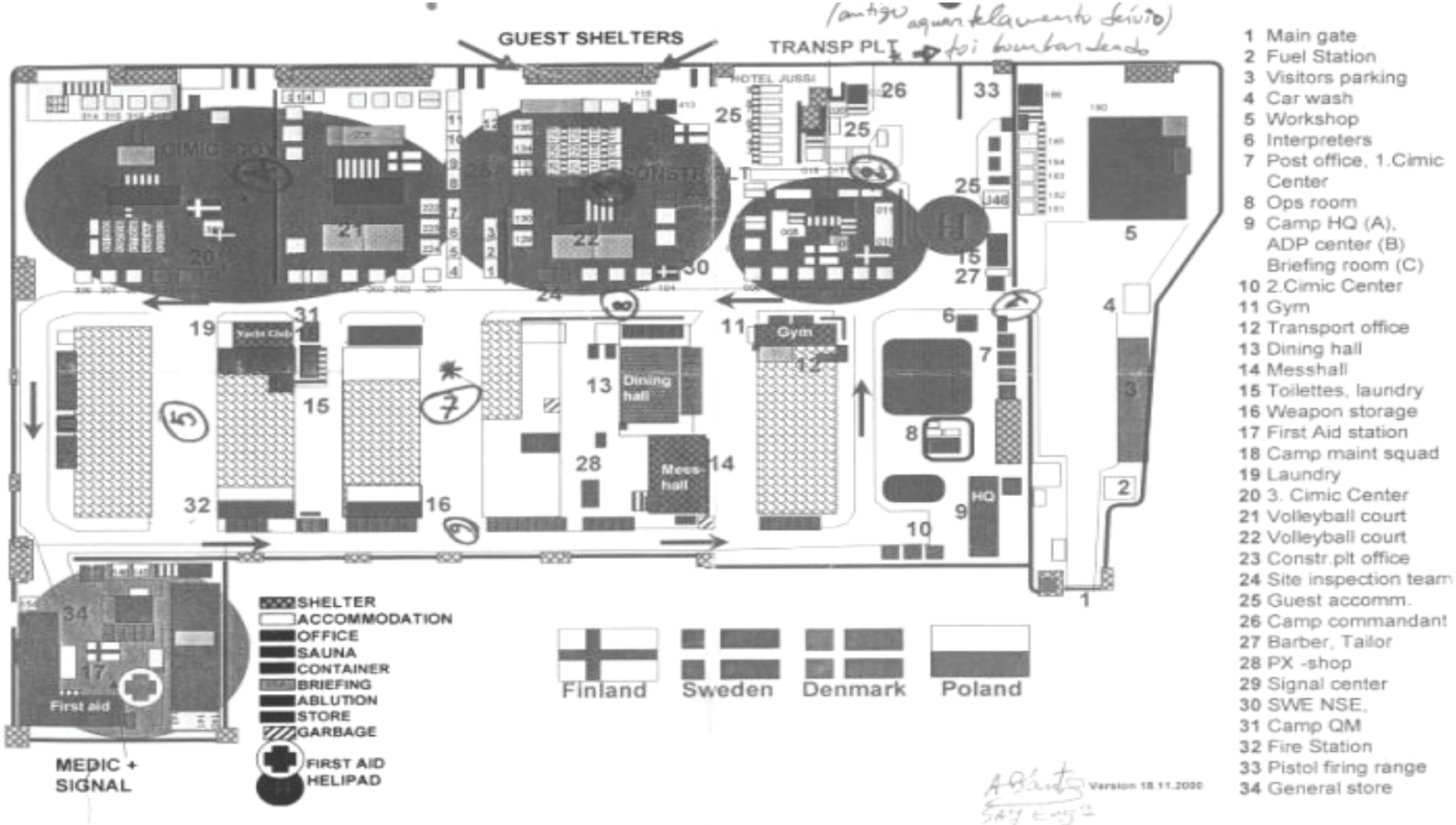


Figure 18 – Plan of Camp Jussi, Doboj, Bósnia Herzegovina. The numbers are the measuring points.

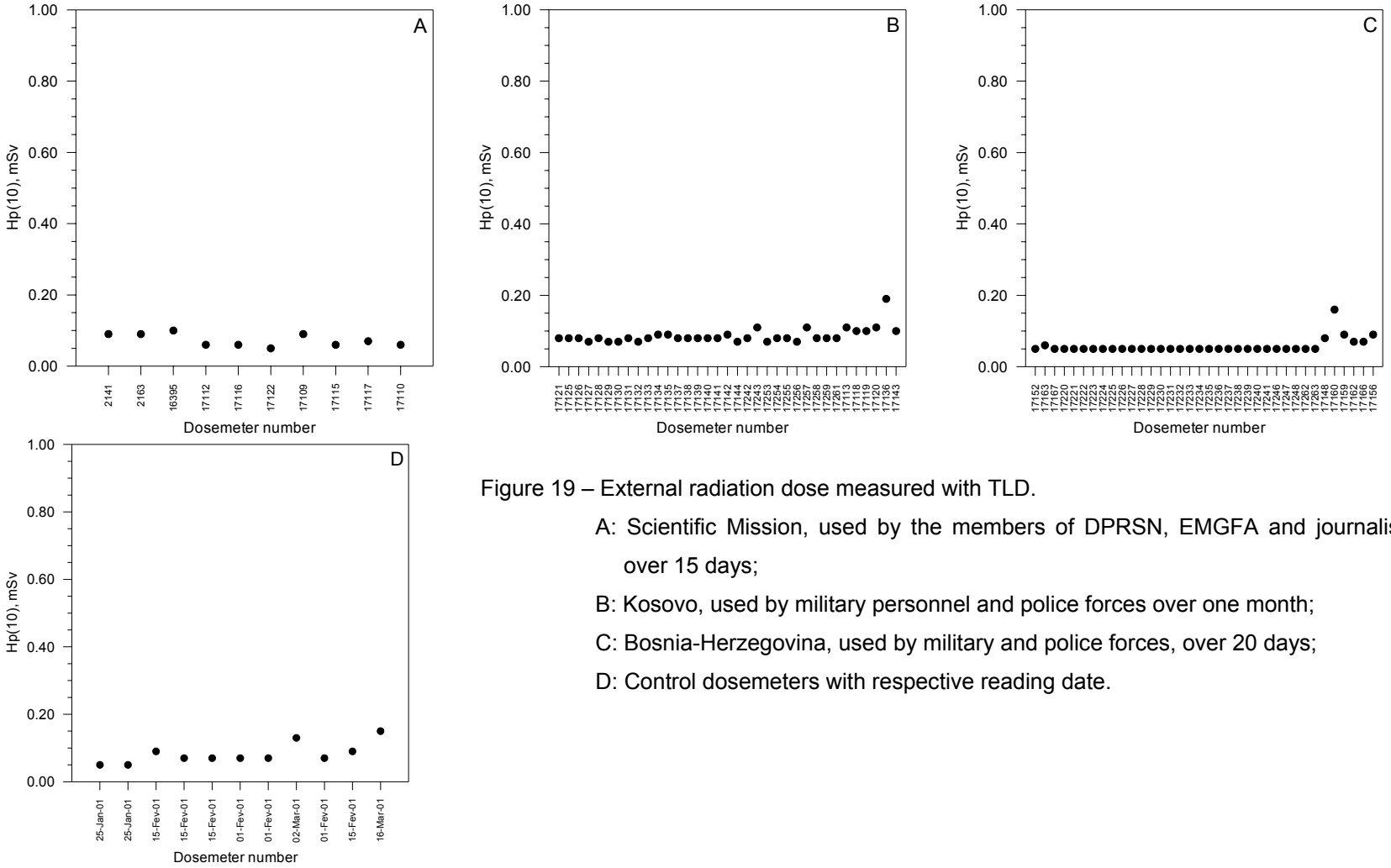


Figure 19 – External radiation dose measured with TLD.

A: Scientific Mission, used by the members of DPRSN, EMGFA and journalist over 15 days;

B: Kosovo, used by military personnel and police forces over one month;

C: Bosnia-Herzegovina, used by military and police forces, over 20 days;

D: Control dosemeters with respective reading date.

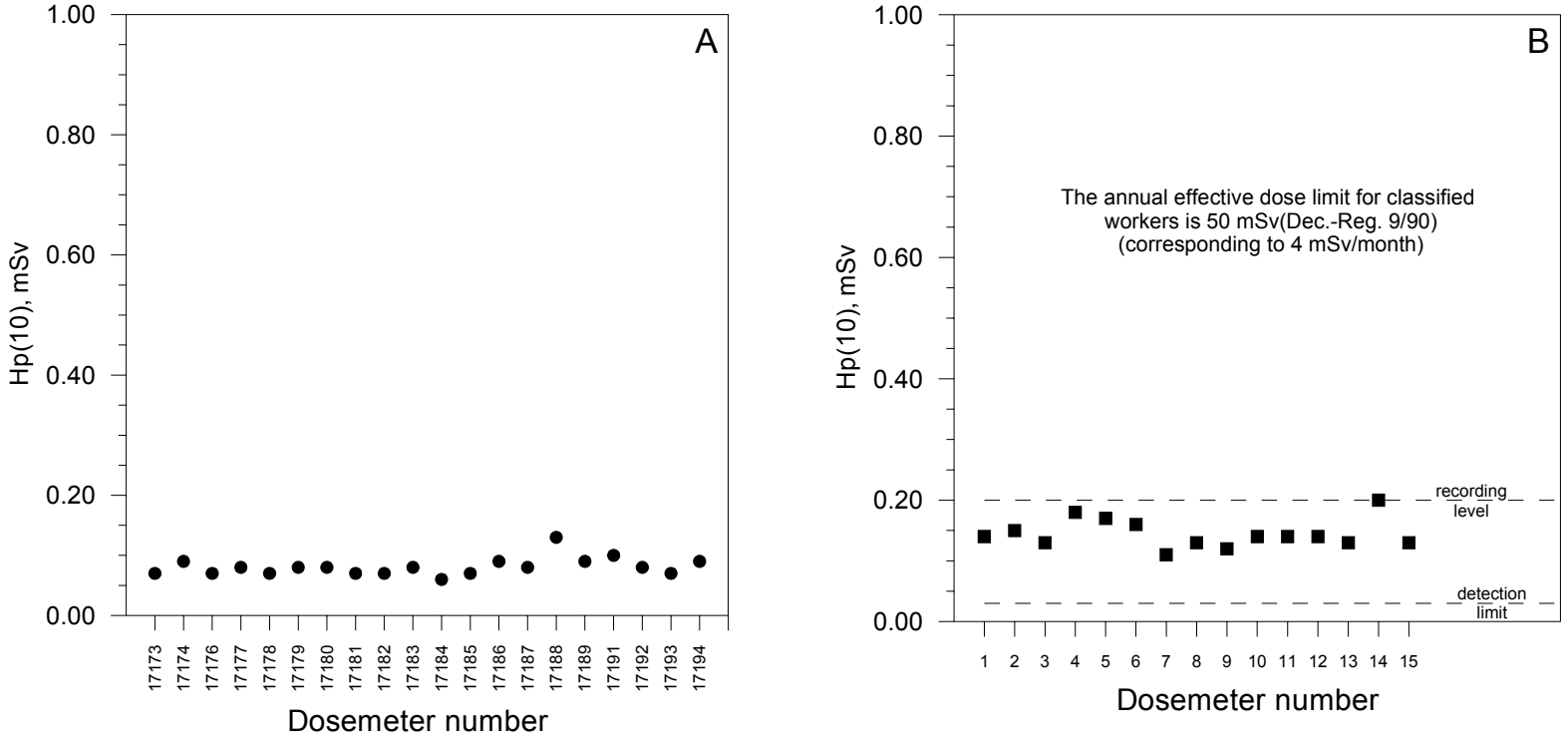
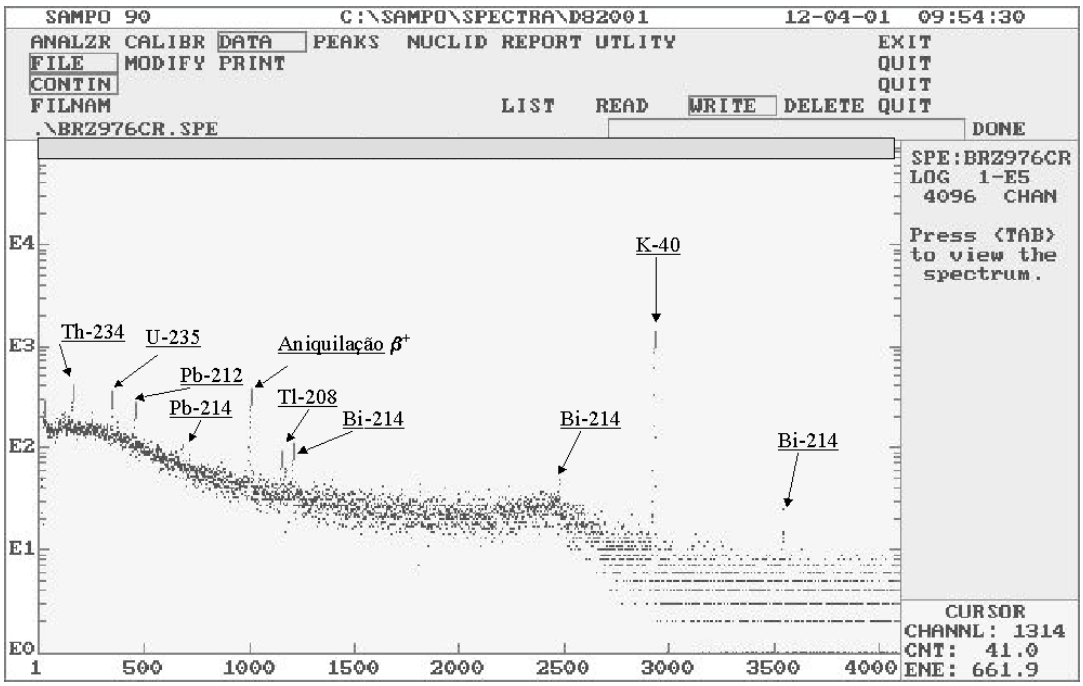


Figure 20 – External radiation dose measured with TLD.

A: Lisboa, used by military personnel from COFT and EMGFA-CAq, in February;

B: Monitoring results for the classified workers at DPRSN. Period of control: December 2000



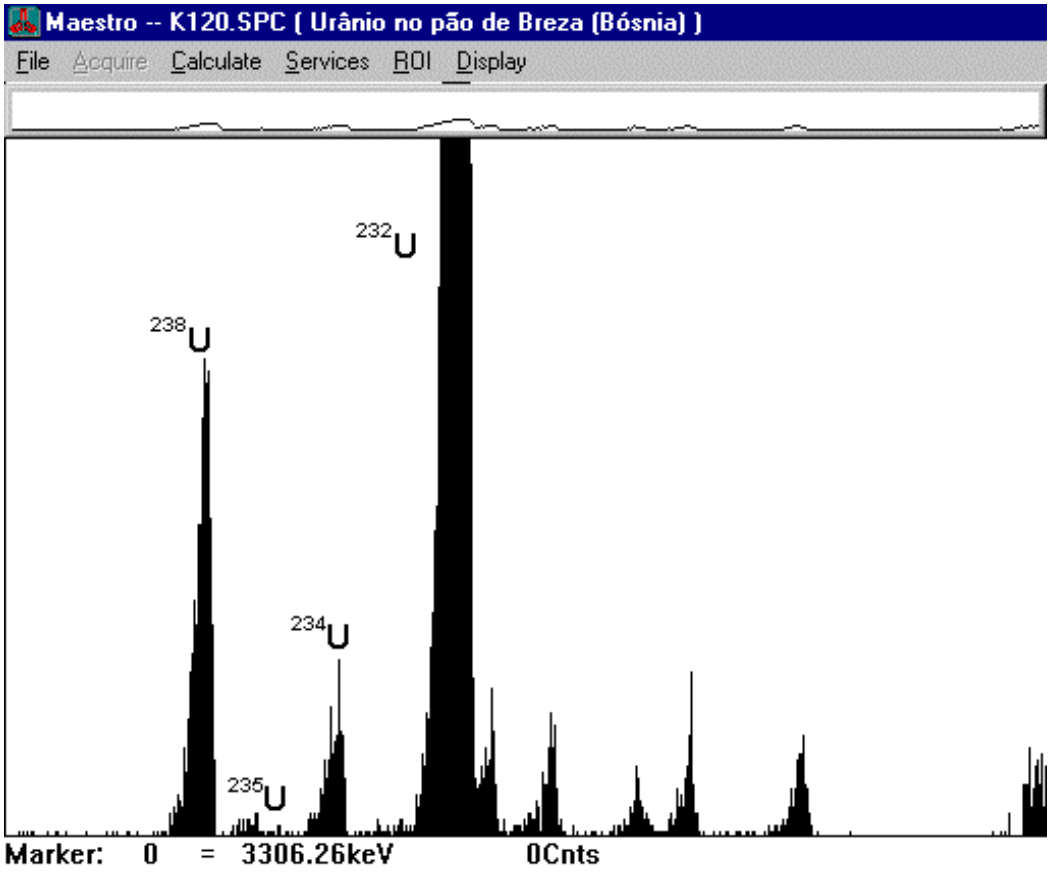


Figure 21 – Analysis of food products.

A. Gamma spectrum of meat sample from Breza.
B. Uranium alpha spectrum of bread sample from Breza.

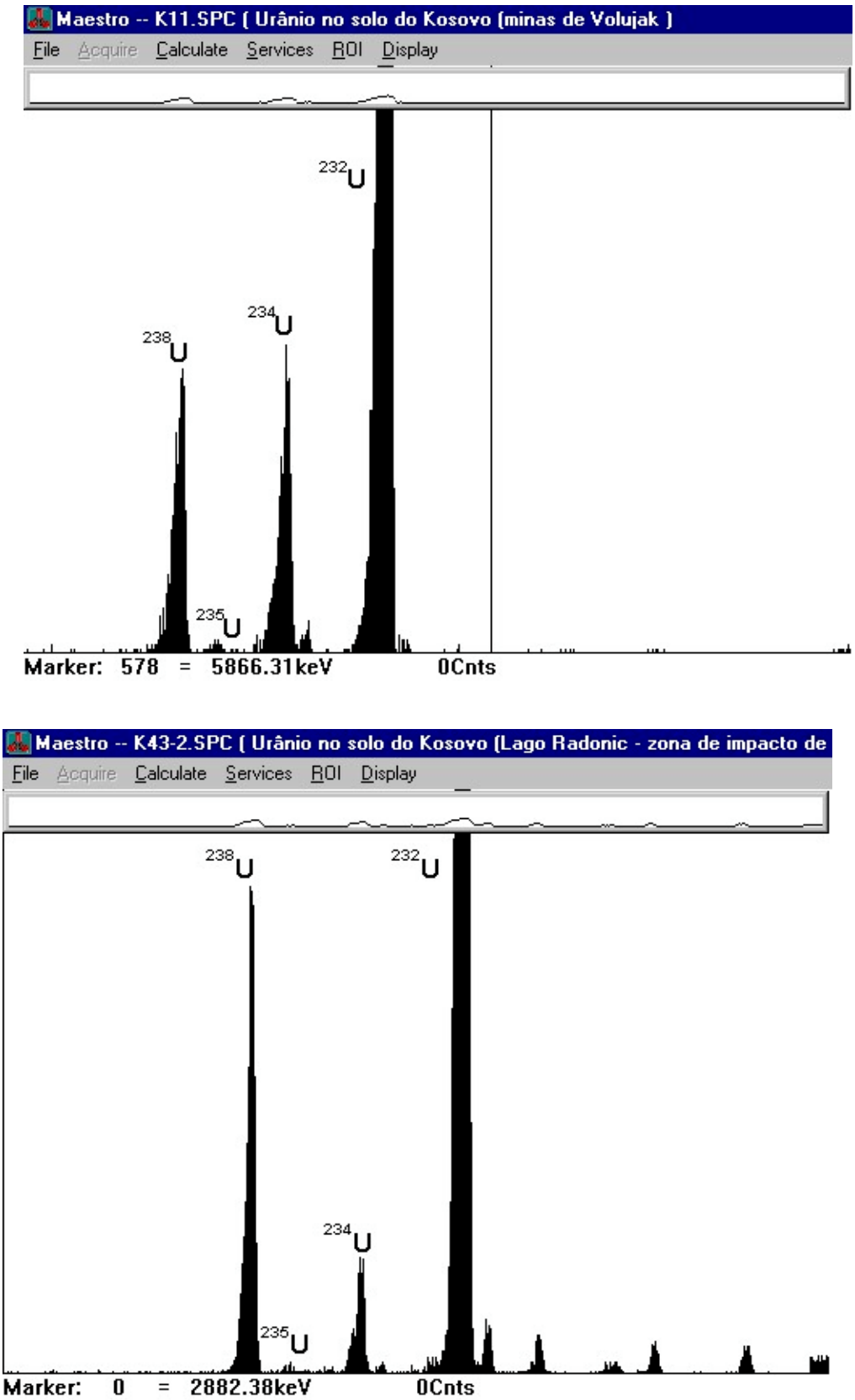


Figure 22 – Uranium alpha spectrum of Kosovo soil samples.

A. Soil from the Volujak mines, station nº 15.
B. Soil from bullet hole, near Lake Radonic, station nº 43.

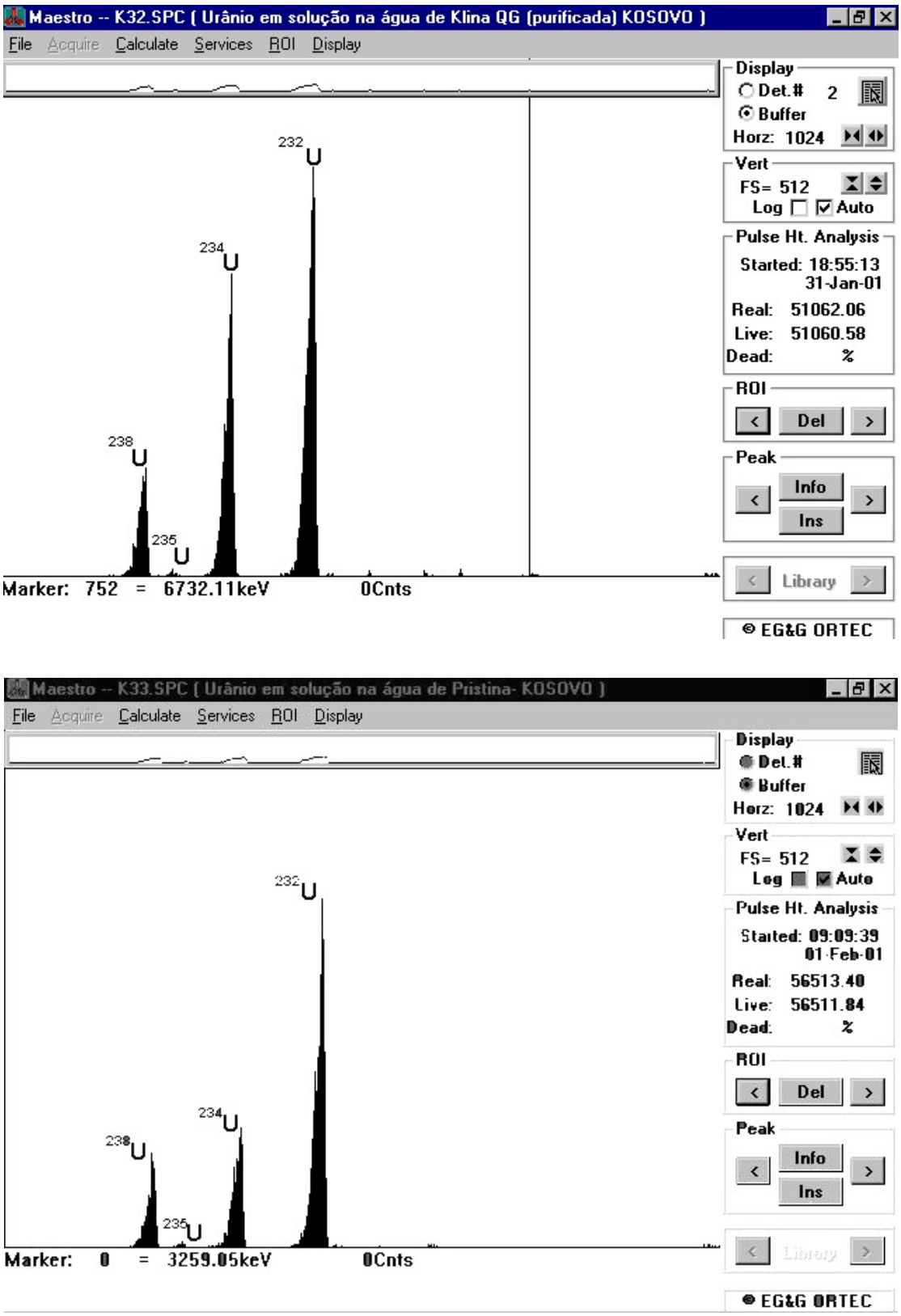


Figure 23 – Spectrograms of two water samples from the Klina barracks (upper) and from Pristina public network (lower). Uranium-232 is added to the sample as isotope carrier. The isotopes detected are ^{238}U, ^{235}U and ^{234}U.

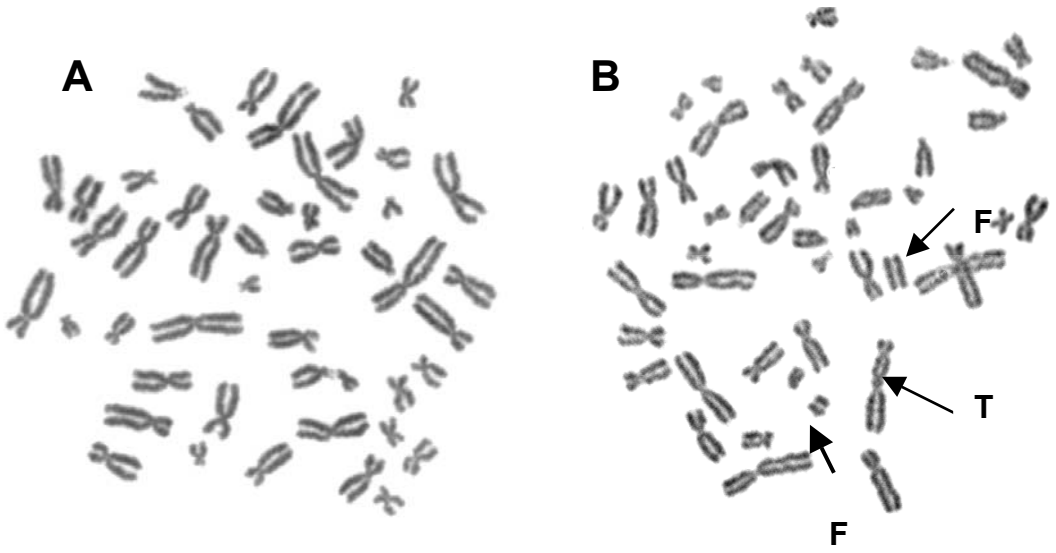


Figure 24 – Search for chromosomic lesions induced by radiations.
A – Set of chromosomes of a cell in metaphase. These cells´ chromosomes are complete and without chromosomic breaks. This is the morphological configuration of a normal cell.
B – Set of chromosomes of a damaged cell, showing breaks and chromosomic recombinations. Two fragments (F) and one tricentric (T) can be observed.

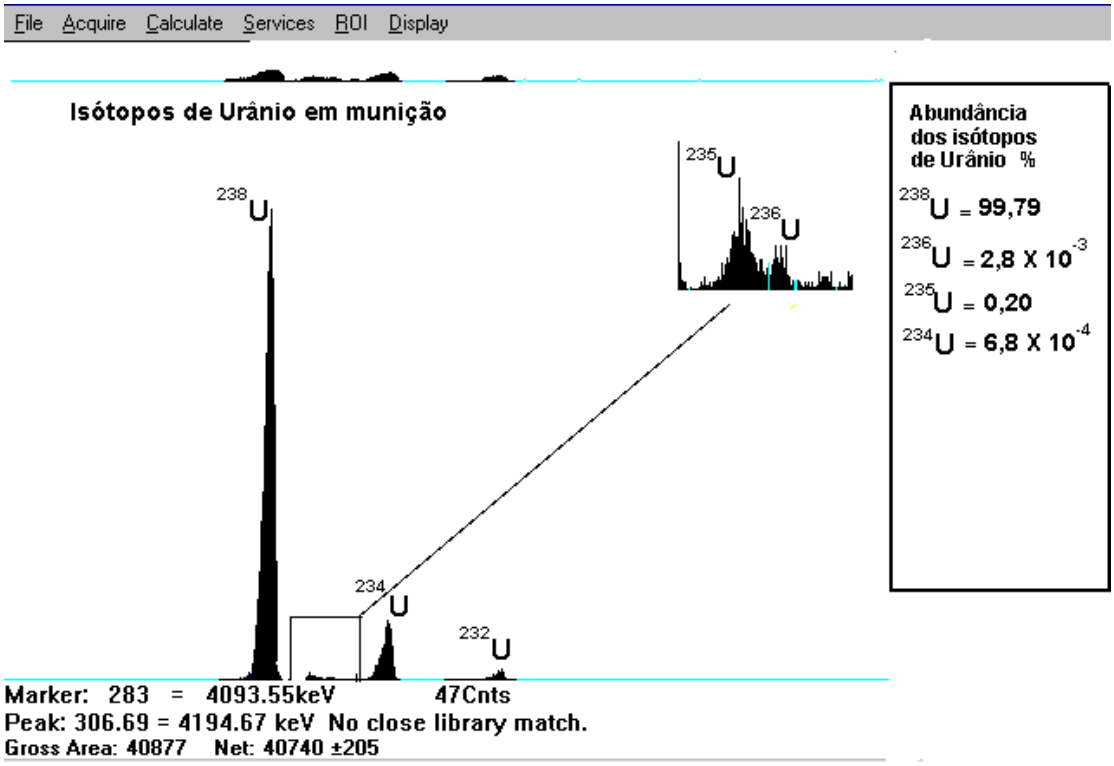


Figure 25 – Uranium analysis of a depleted uranium projectile. Alpha spectrogram and values of the uranium isotopes abundance.

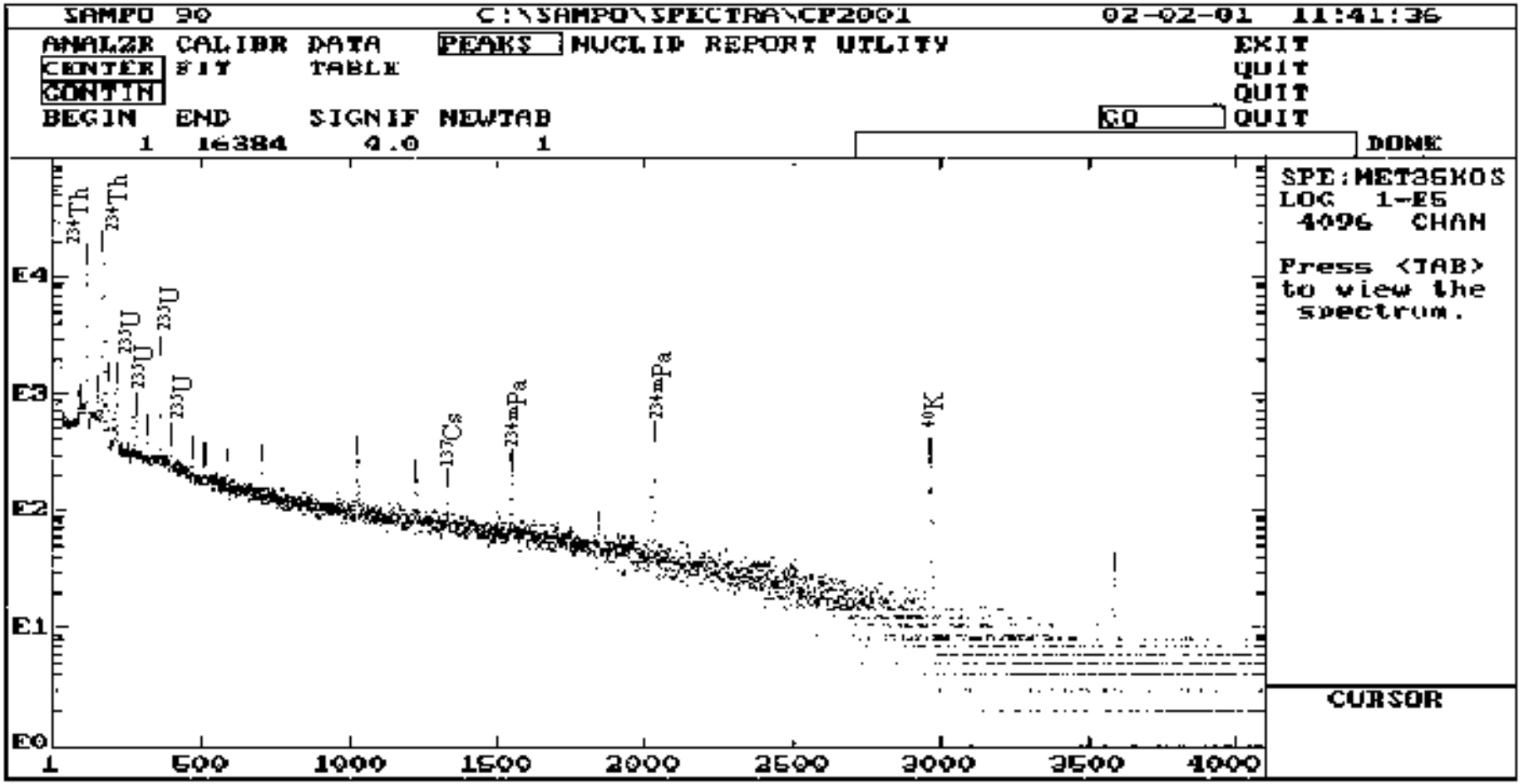


Figure 26 – Analysis of debris collected inside the bullet hole by gamma spectrometry.

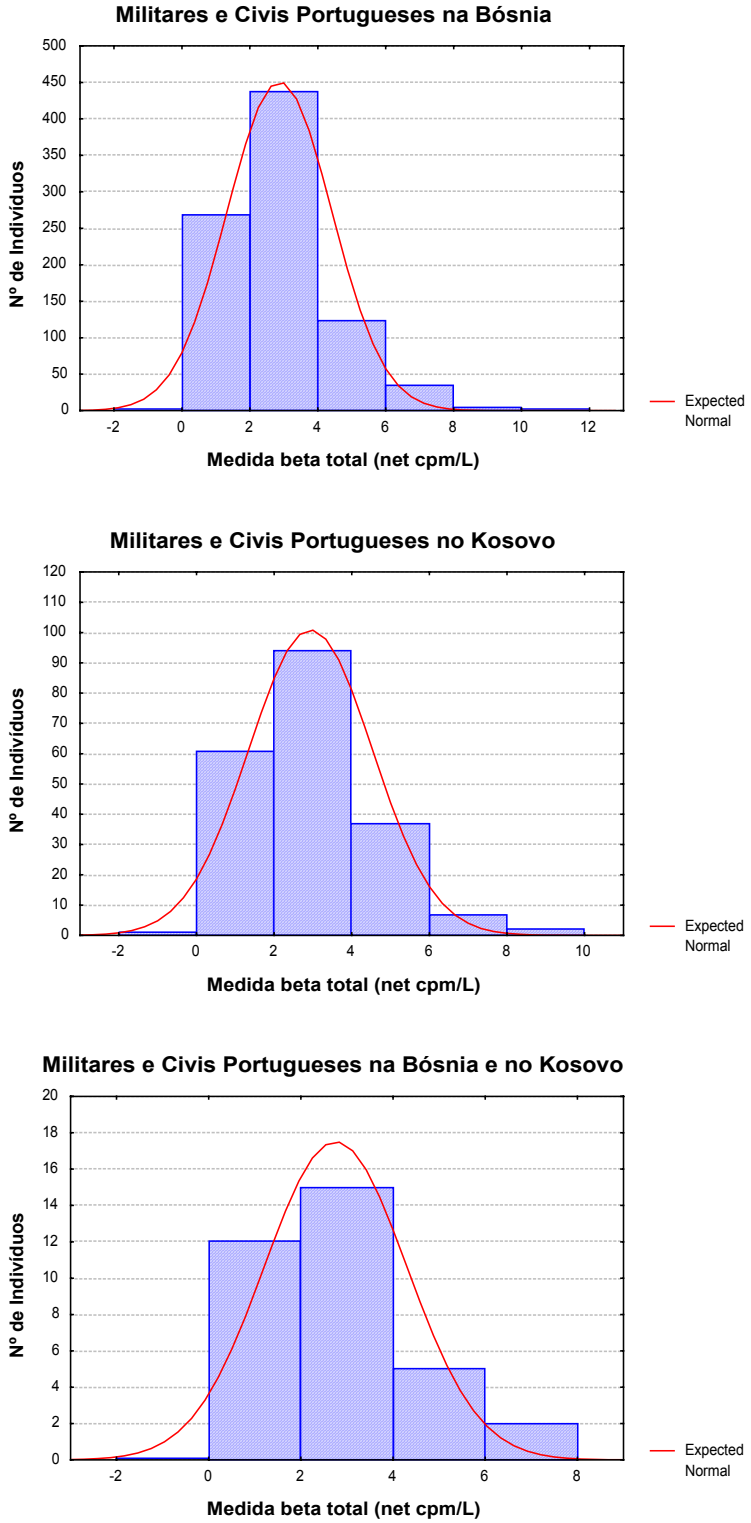


Figure 27 – Uranium activity histograms for 24 hours urine, in net counts per minute per litre (net cpm L^{-1}), for Portuguese military personnel and civilians who served in Balkans. The lower graphic corresponds to military personnel and civilians who carried out missions at Bosnia and Kosovo, not included in the graphics for the Bosnia and Kosovo groups.

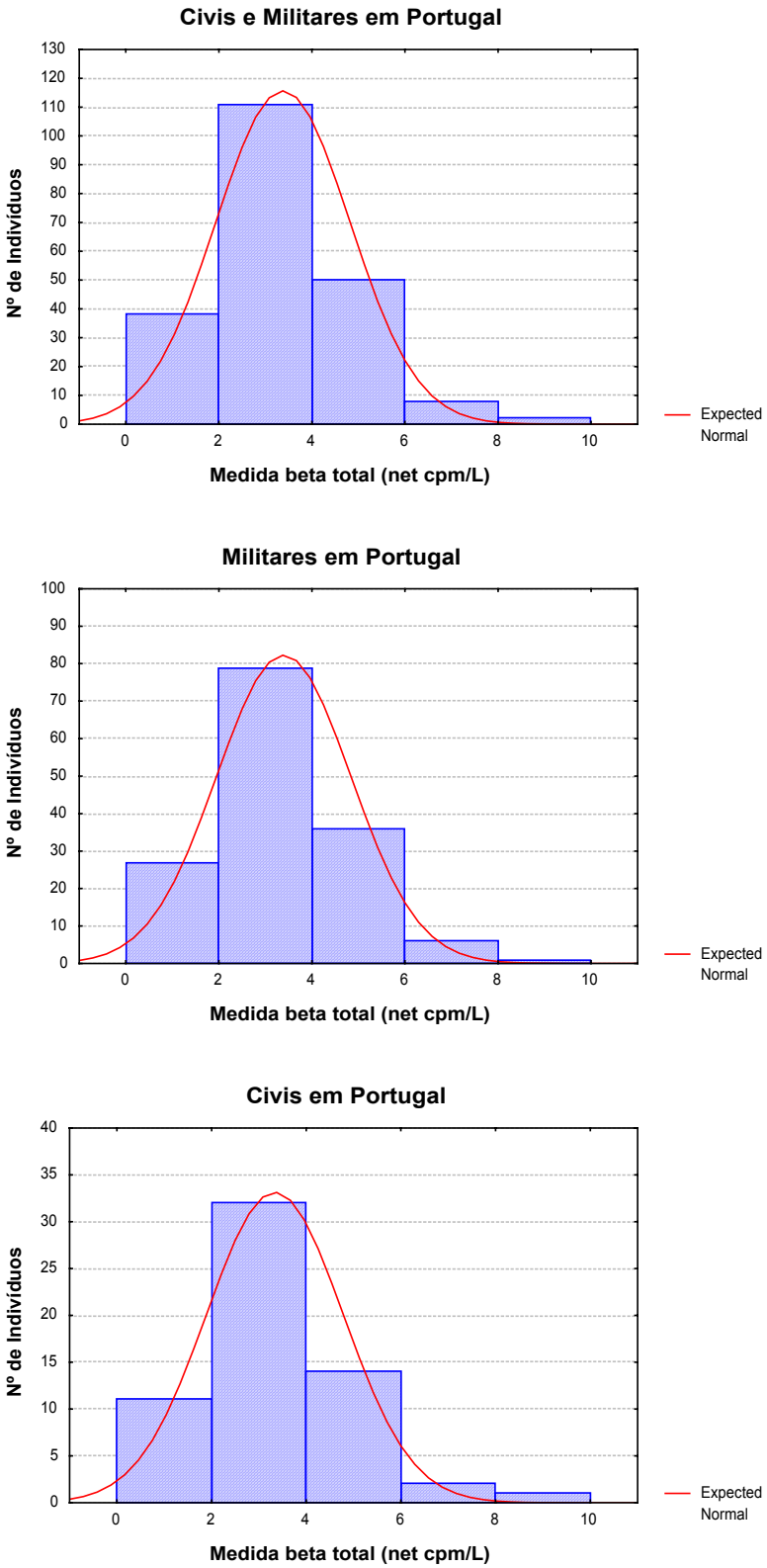


Figure 28 – Uranium activity histograms for 24 hours urine, in net counts per minute per litre (net cpm L^{-1}), for Portuguese military personnel and civilians who had not been at Balkans. In the higher graphic the results for civilians and military persons are grouped.

10 TABLES

TABLES

Table 1. Sampling points in Kosovo.

Sampling Point Number	Location (date)	Co-ordinates Lat (N) Long (E)	Altitude (m)	Work Carried out/ samples
1	KLINA "D. Afonso Henriques" Barracks (5 a 6-1-2001)	42º 37.605' 20º 35.241'		Aerosol Sampling Radiation Measurements Washing water (See detailed map)
2	PEC Multinational Brigade HQ (PEC 1) (6-1-2001)	42º 39.568' 20º 17.378'	543	Radiation Measurements
	PEC - Bridge (PEC 2)	42º 39.568' 20º 17.619'	541	Radiation Measurements
	PEC – Monastery Plaza (PEC 3)	42º 39.593' 20º 17.657'	483	Radiation Measurements
	PEC – Market Street (PEC 4)	42º 39.659' 20º 17.569'	520	Radiation Measurements
	PEC – Garden in front of Astoria Hotel (PEC 5)	42º 39.567' 20º 17.377'	545	Radiation Measurements
	PEC – Road to Banja (PEC 6)			Radiation Measurements
	PEC – Rural land near the road (PEC 7)	42º 41.046' 20º 19.366'	506	Soil Sampling Radiation Measurements
	PEC – Bombarded barracks near the road, South exit (PEC 8)	42º 38.955' 20º 17.534'	518	Soil Sampling Radiation Measurements
3	BANJA (Banja 1) Unused plot of land (6-1-2001)	42º 43.318' 20º 23.307'		Soil Sampling Radiation Measurements
	BANJA (Banja 2) "G.O.E." Barracks			Radiation Measurements
4	DECANI (6-1-2001)	42º 31.363' 20º 18.196'	591	Soil Sampling Radiation Measurements

Table 1 – Continuation.

Sampling Point Number	Location (date)	Co-ordinates Lat (N) Long (E)	Altitude (m)	Work Carried out/ samples
5	SKIVJAN (6-1-2001)	42º 25.486' 20º 23.436'		Soil Sampling Radiation Measurements
6	DJAKOVICA (Djak 1) Bombarded barracks	42º 22.304' 20º 25.376'		Soil Sampling Radiation Measurements
7	DJAKOVICA (Djak 2) Field near the water course bombarded spot	42º 23.608' 20º 26.750'	397	Soil Sampling Radiation Measurements
8	BERKOVO (# 1) Rural Soil	42º 41.004' 20º 30.972'	409	Soil Sampling Radiation Measurements
9	BUDISAVCI Monastery (# 2)	42º 39.877' 20º 29.339'	436	Soil Sampling Aerosol Sampling Radiation Measurements
10	KRUSEVO (# 3) Bombarded airfield	42º 38.173' 20º 29.985'	488	Soil Sampling Radiation Measurements
11	JAGODA (# 4) Village and rural field	42º 38.411' 20º 31.906'	413	Soil Sampling/Profile Radiation Measurements
12	River BELI DRIM (# 5) near "Novo Slozainovo"	42º 36.550' 20º 33.994'	394	Soil and River Water Sampling Radiation Measurements
13	Beginning of the "By-pass" to Prlina (# 6)	42º 36.463' 20º 34.581'	380	Soil Sampling Radiation Measurements
14	"Golfo 01" Point (# 7) Portuguese check point in 2000	42º 35.463' 20º 35.049'	399	Radiation Measurements
15	Volujak Mines (# 8) Bombarded facilities	42º 33.537' 20º 36.139'		Soil Sampling Radiation Measurements
16	Volujak Mines Hill, Bombarded military positions	42º 33.447' 20º 36.069'	629	Radiation Measurements
17	DUS City(# 9) Hill, Bombarded Serbian military positions, granitic soil (7-01-2001)	42º 31.992' 20º 35.302'	585	Soil Sampling Radiation Measurements

Table 1 – Continuation.

Sampling Point Number	Location (date)	Co-ordinates Lat (N) Long (E)	Altitude (m)	Work Carried out/ samples
18	Bombarded field, near Volujak village (# 10)	42º 32.350' 20º 35.399'	561	Soil Sampling Radiation Measurements
19	SVRHE village (# 11) Town plaza; bombarded military targets in the hills (100 to 200 m far)	42º 32.971' 20º 36.942'	564	Soil Sampling Radiation Measurements
20	RIDEVO (# 12) Rural field, near village (7-1-01)	42º 35.230' 20º 41.623'	616	Soil Sampling Radiation Measurements
21	STARIKA (# 13) Check point at 1km from Duceviç, rural field (7-1-01)	42º 37.410' 20º 40.442'	476	Soil Sampling Radiation Measurements
22	JOSANICA 2 (# 14) Former Check point Lordelo	42º 39.100' 20º 37.940'	492	Soil Sampling Radiation Measurements
23	BICA (# 15) Destroyed Serbian village	42º 40.732' 20º 36.011'	516	Soil Sampling Radiation Measurements
24	Rural elevated plain on the road to Renovac (#16) (7-1-01)	42º 40.528' 20º 34.467'	529	Soil Sampling Radiation Measurements
25	RENOVAC (# 17) Renovica creek	42º 40.030' 20º 33.034'	422	Soil Sampling Radiation Measurements
26	ZLOCUKANE (# 18)	42º 39.608' 20º 32.521'	411	Soil Sampling Radiation Measurements
27	KLINA (# 19) North entrance (Ciganska Mah)	42º 37.816' 20º 34.156'	412	Soil Sampling Radiation Measurements
28	KLINA (# 20) Street to Portuguese barracks	42º 37.435' 20º 35.070'		Soil Sampling Radiation Measurements
29	PRLINA (# 21) Bus station; bombarded Military vehicles (8-1-01)	42º 36.548' 20º 34.568'	400	Soil Sampling Radiation Measurements
30	KIJEVO (# 22) Russian check point, Wracked bridge	42º 33.844' 20º 46.308'	668	Soil Sampling Radiation Measurements

Table 1 – Continuation.

Sampling Point Number	Location (date)	Co-ordinates Lat (N) Long (E)	Altitude (m)	Work Carried out/ samples
31	NEGROVCE (DURDIKA) (# 23) near Serbian fire camp	42º 35.958' 20º 57.825'	661	Soil Sampling Radiation Measurements
32	PRISTINA (# 24) South entrance, fuel station	42º 39.400' 21º 08.672'	622	Soil Sampling Radiation Measurements
33	PRISTINA (# 25) KFOR HQ, near Portuguese accommodations (8-1-01)	42º 39.861' 21º 08.722'	657	Soil Sampling Aerosol Sampling Radiation Measurements
34	PRISTINA (# 26) Near Serbian Police HQ, bombarded	42º 39.752' 21º 09.484'	615	Radiation Measurements
35	PRISTINA (# 27) Central post office, bombarded	42º 39.900' 21º 09.776'	618	Radiation Measurements
36	VUSTRIN (# 28) (8-1-01)	42º 48.874' 20º 59.012'	549	Soil Sampling Radiation Measurements
37	TRERÇA Factories (# 29) Industrial complex (chemical and metallurgical) at south of Mitrovica, Not bombarded	42º 52.636' 20º 52.776'	521	Radiation Measurements
38	MITROVICA (# 30) Town centre	42º 53.242' 20º 52.052'	523	Radiation Measurements
39	MITROVICA (# 31) West exit, country side	42º 51.533' 20º 50.352' (8-1-01)	596	Soil Sampling Radiation Measurements
40	RUDNICK (# 32) Hills	42º 47.503 20º 42.040'	735	Soil Sampling Radiation Measurements
41	DURAKOVAC (# 33)	42º 43.621' 20º 28.889'	457	Soil Sampling Radiation Measurements
42	Lake RADONIC (# 34) Artificial lake (9-1-01)	42º 28.736' 20º 26.157'	467	Soil Sampling Water Sampling Radiation Measurements

Table 1 – Conclusion.

Sampling Point Number	Location (Date)	Co-ordinates Lat (N) Long (E)	Altitude (m)	Work Carried out/ Samples
43	Lake RADONIC (# 35) Road and facilities, bombarded spots with DU	42º 28.272' 20º 25.892'	497	Soil Sampling Pieces of Metal (Ammunition?) Sampling Radiation Measurements
44	PRIZREN (# 36) Bridge near the town	42º 21.194' 20º 32.509'	387	Soil Sampling Radiation Measurements
45	KRAJK (# 37) Beli Drim River	42º 16.797' 20º 39.878'	331	Soil Sampling Water River Sampling Radiation Measurements
46	ZUR (# 38) Hills over Zur village, former Serbian position bombarded, mined area	42º 10.401' 20º 36.400'	543	Soil Sampling Radiation Measurements
47	PRIZREN (# 39) Town centre			Public Water Sampling Radiation Measurements
48	SUVA REKA (# 40)	42º 20.902' 20º 49.075'	432	Soil Sampling Radiation Measurements
49	BELIN (# 41)	42º 27.478' 20º 58.716'	643	Soil Sampling Radiation Measurements
50	LIPJAN (# 42)	42º 32.367' 21º 07.243'	562	Soil Sampling Radiation Measurements

Table 2. Sampling points in Bosnia-Herzegovina.

Sampling Point Number	Location (date)	Co-ordinates Lat (N) Long (E)	Altitude (m)	Work Carried out/ samples
1	VISOKO Military camp, Portuguese barracks (2º BIMEC) (11-01-01)	43º 59.997' 18º 09.659'	443	Aerosol Sampling Soil Sampling Public Water Sampling Radiation Measurements (See detailed plan)
2	Public water supply for consumption in Visoko and Portuguese military	43º 57.921' 18º 11.045'	443	Soil Sampling Water Sampling Radiation Measurements
3	BREZA IPTF Station	44º 00.286' 18º 15.431'	491	Soil Sampling Radiation Measurements
4 a	VISOKO – town entrance. 2 km from Visoko camp	43º 59.472' 18º 10.941'	441	Radiation Measurements
b	Visoko – centre. Near hospital and gym	43º 59.643' 18º 10.522'	440	Radiation Measurements
c	Visoko – football camp. Used as helicopter airport	44º 00.390' 18º 09.563'	427	Soil Sampling Radiation Measurements
5	ROGATICA Ex-HQ of the Portuguese battalion (until March 2000)	43º 47.988' 19º 00.146'	543	Aerosol Sampling Soil Sampling Radiation Measurements
6	VITKOVICI Fertilizers factory, in front of the Portuguese ex-HQ	43º 37.605' 18º 57.839'	536	Soil Sampling Radiation Measurements
7	VITKOVICI Portuguese ex-barracks	43º 37.633' 18º 57.862'	376	Soil Sampling Radiation Measurements (See detailed plan)
8	MILJENO Bridge near Cajnice, bombarded	43º 35.600' 19º 01.969'	613	Soil Sampling Radiation Measurements
9	GORADZE City plaza, used by Portuguese military	43º 40.140' 18º 58.477'	361	Soil Sampling Public Water Sampling Radiation Measurements

Table 2 – Continuation.

Sampling Point Number	Location (date)	Co-ordinates Lat (N) Long (E)	Altitude (m)	Work Carried out/ samples
10	JABUKA Military antenna, wracked by a tomahawk missile, position used by Portuguese military between 1996 and 2000	43º 43.058' 18º 59.710'	1221	Soil Sampling Radiation Measurements
11	PRACA Position used by Portuguese military in 1996	43º 46.152' 18º 45.023'	713	Soil Sampling Radiation Measurements
12	USTIPRACA Barracks	43º 41.469' 19º 05.285'	401	Soil Sampling Radiation Measurements
13	Bridge to MEDADA Portuguese check point, mined zone	43º 43.933' 19º 10.877'	378	Radiation Measurements
14 a	VISEGRAD Near river bridge, north margin of Drina River	43º 47.405' 19º 17.806'	338	Food Sampling Soil Sampling Public Water Sampling Radiation Measurements
b	VISEGRAD South margin of Drina River.	43º 47.368' 19º 17.501'	315	Radiation Measurements
15	ZHARID Barracks near Rogatica	43º 47.529' 18º 59.888'	711	Soil Sampling Radiation Measurements (see detailed plan)
16	DOBOJ Camp Dannevirque	44º 40.952' 18º 04.343'	170	Soil Sampling Radiation Measurements (see detailed plan)
17	DOBOJ Camp Jussi	44º 43.031' 18º 05.043'	167	Soil Sampling Radiation Measurements (see detailed plan)
18	DOBOJ Transmission antenna	44º 45.536' 18º 07.503'	572	Soil Sampling Radiation Measurements
19	GRACANICA	44º 41.609' 18º 18.708'	207	Soil Sampling Public Water Sampling Radiation Measurements
20	ZAVIDOVICI	44º 30.579' 18º 04.899'	201	Soil Sampling

Table 2 – Continuation.

Sampling Point Number	Location (date)	Co-ordinates Lat (N) Long (E)	Altitude (m)	Work carried out/ samples
21	ZENICA In front of Europe largest siderurgy	44º 14.215' 17º 53.912'	338	Soil Sampling Radiation Measurements
22	ZETRA (Zehra Muidoviç) Former Portuguese position in the hills over the Sarajevo Olympic stadium	43º 52.645' 18º 24.443'	335	Soil Sampling Radiation Measurements
23	TITO BARRACKS Italian Brigade HQ	43º 51.536' 18º 23.660'	335	Soil Sampling Radiation Measurements
24	ILIDZÁ Bosna River spring	43º 49.079' 18º 16.132'	526	Soil Sampling Radiation Measurements
25	Road to PALE. Hills over the south side of Sarajevo, bombarded Serbian positions, mined zone	43º 50.599' 18º 24.950'	814	Soil Sampling Radiation Measurements
26	Road to PALE. Hills over the south side of Sarajevo, bombarded Serbian positions, mined zone	43º 50.508' 18º 25.895'	939	Soil Sampling Radiation Measurements
27	BUTMIR SFOR HQ (16-01-01)	43º 48.847' 18º 20.620'	529	Aerosol Sampling Soil Sampling Radiation Measurements
28	RAJLOVAC SFOR Military Hospital (17-01-01)	43º 52.096' 18º 18.525'	500	Radiation Measurements
29	HADZICI Serbian military equipment Factory, box with DU ammunitions recovered in 1996	43º 49.379' 18º 11.611'	576	Soil Sampling Radiation Measurements
30	HRASNICA "FAMOS" Factory (chemical and metallurgical), bombarded, unsafe storage of 50-60 Ton. of cyanide	43º 47.583' 18º 19.753'	537	Soil Sampling Radiation Measurements
31	HADZICI Croatian-Muslim Federation Barracks, building area	43º 48.703' 18º 12.428'	589	Aerosol Sampling Soil Sampling Radiation Measurements

Table 2 – Conclusion.

Sampling Point Number	Location (date)	Co-ordinates Lat (N) Long (E)	Altitude (m)	Work carried out/ samples
32	HADZICI Croatian-Muslim Federation Barracks, weapon storage, bombarded, mined zone	43º 48.059' 18º 13.160'	725	Soil Sampling Radiation Measurements
33	HADZICI Croatian-Muslim Federation Barracks, weapon storage, bombarded, mined zone	43º 48.231' 18º 13.231'	691	Soil Sampling Radiation Measurements
34	BRADINA Exit to Mostar, land near the road	43º 44.114' 18º 00.688'	690	Soil Sampling Radiation Measurements
35	OSTROZAC Exit to Mostar, parking near the road	43º 40.362' 17º 46.347'	326	Soil Sampling Radiation Measurements
36	MOSTAR – Brigade HQ Southeast brigade HQ, main gate	43º 17.363' 17º 50.127'	70	Soil Sampling Radiation Measurements

Table 3 – Results obtained by the DPRSN in an Intercomparison exercise. Analysis by alpha spectrometry.

	Reference Value (Bq kq^{-1}) Mean and Interval of 95%	**Results of DPRSN**
WHO Sample nº 65 SR 300 (lacustrine sediment)		
YEAR: 1999		
^{238}U	2750 ± 210	2844 ± 66
^{235}U	127.8 ± 8.8	135.8 ± 6.5
^{234}U	2765 ± 220	2928 ± 68
Sample IAEA 384 (marine sediment)		
YEAR: 2000		
^{238}U	36.4 (33.4 – 37.3)	35 ± 1
^{235}U	1.76 (1.69 – 2.00)	2.0 ± 0.1
^{234}U	40.3 (35.2 – 43.0)	41.0 ± 1.0
^{238}Pu	39.0 (38.1 – 40.1)	39.0 ± 1.0

Table 4 – Results from external monitoring in Kosovo corrected for equipment efficiency.

Sampling Point Number	Location	Dose Rate of External Radiation γ Emitters μSv/h (a)	Surface Contamination α, β and γ Emitters c/s (b)	Surface Contamination α Emitters c/s (c)	Surface Contamination α Emitters c/s (d)
1	Barracks	0.06	4		
2	Pec 1	0.06	2	0.2	
2	Pec 2	0.08	2	0.2	
2	Pec 3	0.06	2	0.2	
2	Pec 4	0.04	2	0.2	
2	Pec 6	0.08	2	43 (?)	
2	Pec 7	0.16	2	0.4	
2	Pec 8	0.10	2	0.2	
3	Banja 1	0.16	2	0.2	
3	Banja 2	0.22	2	0.4	
4	Decani	0.16	2	0.2	
5	Skivjan	0.18	2	0.2	
6	Djakovica	0.18	11	0.4	
7	Djakovica	0.10	2	0.2	
8	Berkovo	0.22	2		0.2
9	Budisavci Monastery	0.12	3		0.2
10	Krusevo	0.10	2		0.2
11	Jagoda	0.10	4		0.2
12	Rio Beli Drim	0.12	2		0.2
13	“By-Pass”	0.08	4		0.2
14	“Golfo 01”	0.10	2		0.2
15	Volujak Mines	0.16	5		0.3
16	Volujak Mines	0.18	2		0.2
17	DUZ	0.46	2		0.2

Table 4 – Continuation.

Sampling Point Number	Location	Dose Rate of External Radiation	Surface Contamination		
		γ Emitters μSv/h (a)	α, β and γ Emitters c/s (b)	α Emitters c/s (c)	α Emitters c/s (d)
18	Volujak	0.40	2		0.2
19	Svrhe	0.80	2		0.2
20	Ridevo	1.18	5		0.2
21	Starika	1.04	4		0.2
22	Josanica	0.84	3		0.2
23	Bica	0.72	2		0.2
24	Elevated Plain	0.52	4		0.2
25	Renovac	0.54	3		0.2
26	Zlocukane	0.38	2		0.2
27	Klina	0.50	2		0.2
28	Klina	0.32	2		0.2
29	Prlina	0.18	2		0.2
30	Kijevo	0.08	2		0.4
31	Negrovce	0.10	2		0.2
32	Pristina	0.18	2		0.2
33	Pristina	0.16	2		0.2
34	Pristina	0.28	2		0.2
35	Pristina	0.26	2		0.2
36	Vustrin	0.30	2		0.2
37	Trerça Factories	0.12	2		0.2
38	Mitrovica	0.16	2		0.2
39	Mitrovica	0.22	2		0.2
40	Rudnick	0.26	2		0.2
41	Durakovac	0.42	2		0.2
42	Lake Radonic	0.26	2		0.2

Table 4 – Conclusion.

Sampling Point Number	Location	Dose Rate of External Radiation	Surface Contamination		
		γ Emitters μSv/h (a)	α, β and γ Emitters c/s (b)	α Emitters c/s (c)	α Emitters c/s (d)
43	Lake Radonic	0.14	2		0.2
44	Prizren	0.94	2		0.2
45	Krajk	0.34	2		0.2
46	Zur	0.26	5		0.2
48	Suva Reka	0.22	2		0.2
49	Belin	0.20	2		0.2
50	Lipjan	0.18	2		0.2

Ionization Chamber Victoreen 450P nº 1210
Contamination Monitor DS 501 nº 84 (natural background between 1 and 3 c/s)
Contamination Monitor MIP 10 nº 7286 + SAP 400 nº178 (natural background 0.2 c/s)
Contamination Monitor MIP 10 nº 7286 + SA70-2 nº194 (natural background 0.2 c/s)
c/s abbreviation of counts per second

Table 5 – Results from external monitoring at the Portuguese "D. Afonso Henriques" Barracks in Klina (Kosovo), corrected for equipment efficiency. See picture 9 for the location of the measuring points.

Point Nº	Place	Dose Rate of External Radiation α Emitters μSv/h (a)	Surface Contamination α, β and γ Emitters counts/second (b)	Surface Contamination α, β and γ Emitters Counts/second (c)
1	Football Camp	0.04	2	3
2	Weapon Storage	0.06	2	2
3	Well	0.06	2	4
4	Vehicle Wash	0.06	2	2
5	Gym	0.06	3	4
6	Command	0.06	2	2
7	Accommodations	0.06	2	2
8	Mess Hall	0.06	3	3
9	Kitchen	0.06	2	2
10	Main Gate	0.06	2	2
11	PX Store	0.06	2	2
12	Bar	0.06	2	2
13	Engineering	0.06	2	2
14	Street (walk)	0.06	2	2
15	Street (walk)	0.06	2	2
16	Street (walk)	0.06	2	2
17	Team Base	0.04	2	2
18	Parking	0.06	2	3
19	Workshop	0.06	2	2
20	Fuel	0.06	5	5
21	Main WC	0.06	2	2

Ionization Chamber Victoreen 450P nº 1210
Contamination Monitor DS 501 nº 84 (natural background between 1 and 3 c/s)
Contamination Monitor DS 501 nº 112 (natural background between 1 and 3 c/s)

Table 6 – Results for the individual monitoring of civilian and military personnel in Kosovo corrected for the equipment efficiency.

Identification Number	**Individual Contamination**	
	β and γ Emitters counts/second (a)	**α Emitters counts/seconds (b)**
78	2	0.2
278	2	0.2
161	2	0.2
9	2	0.2
256	2	0.2
45	2	0.2
238	2	0.2
189	2	0.2
122	2	0.2
179	2	0.2
160	2	0.2
166	2	0.2
159	2	0.2
162	2	0.2
146	2	0.2
121	2	0.2
261	2	0.2
264	2	0.2
266	2	0.2
263	2	0.2
269	2	0.2
270	2	0.2
265	2	0.2
123	2	0.2
67	2	0.2

Table 6 – Conclusion.

Identification Number	Individual Contamination	
	β and γ Emitters counts/second (a)	α Emitters counts/second (b)
Volujak Civilian	2	0.2
Klina Civilian	1	0.2
226	1	0.2
283	1	0.2
281	1	0.2
231	1	0.2
247	1	0.2
233	1	0.2
245	1	0.2
235	1	0.2
236	1	0.2
234	1	0.2
279	1	0.2
386	1	0.2
285	1	0.2
287	1	0.2
284	1	0.2
216	1	0.2

Contamination Monitor MIP 10 nº 7286 + SBG n.º 1442 (natural background between 1 and 2 c/s)
Contamination Monitor MIP 10 nº 801 + SA70-2 n.º 194 (natural background 0.2 c/s)

Table 7 – Results form external monitoring in Bosnia-Herzegovina corrected for equipment efficiency.

Sampling Point Number	Location	Dose Rate of External Radiation	Surface Contamination	
		α Emitters μSv/h (a)	α, β and γ Emitters counts/seconds (b)	α Emitters counts/seconds (c)
1	Visoko Military Camp	0.30	3	0.2
2	Buci	0.08	3	0.2
3	Breza	0.10	2	0.2
4a	Visoko	0.24	5	0.2
4b	Visoko	0.24	3	0.2
4c	Visoko	0.12	3	0.2
5	Rogatica	0.18	3	0.2
6	Vitkovici	0.24	2	0.2
7	Vitkovici	0.38	1.5	0.2
8	Miljeno	0.10	2	0.2
9	Goradze	0.10	2	0.2
10	Jabuka	0.14	2	0.2
11	Praca	0.06	3	0.2
12	Ustipraca	0.06	2	0.2
13	Mededa	0.12	2	0.2
14a	Visegrad	0.04	2	0.2
14b	Visegrad	0.08	2	0.2
15	Zharid	0.12	2	0.2
16	Doboj	0.08	1.5	0.2
17	Doboj	0.08	1.5	0.2
18	Doboj	0.06	1.5	0.2
19	Gracanica	0.06	1.5	0.2
20	Zavidovici	0.08	1	0.2
21	Zenica	0.06	1	0.2

Table 7 – Conclusion.

Sampling Point Number	Location	Dose Rate of External Radiation	Surface Contamination	
		α Emitters μSv/h (a)	α, β and γ Emitters counts/second (b)	α Emitters counts/second (c)
22	Zetra	0.10	1	0.2
23	Tito Barracks	0.18	2	0.2
24	Ilidzá	0.10	1	0.2
25	Road to Pale	0.06	1	0.2
26	Road to Pale	0.04	1	0.2
27	Butmir Camp	0.10	1	0.2
28	Rajlovac	0.10	1	0.2
29	Hadzici	0.30	1	0.2
30	Hrasnica	0.08	1	0.2
31	Hadzici	0.10	1	0.2
32	Hadzici	0.22	1	0.2
33	Hadzici	0.10	1	0.2
34	Bradina	0.06	1	0.2
35	Ostrozac	0.06	1	0.2
36	Mostar	0.10	1	0.2

Ionization Chamber Victoreen 450P nº 1210
Contamination Monitor DS 501 nº 84 (natural background between 1 and 3 c/s)
Contamination Monitor MIP 10 nº 7286 + SA70-2 nº194 (natural background 0.2 c/s)

Table 8 – Results from external monitoring at the Portuguese Barracks in Visoko, Bosnia-Herzegovina corrected for equipment efficiency. See pictures 10 to 12 for the location of the measuring points.

Point Number	Place	Dose Rate of External Radiation γ Emitters μSv/h (a)	Surface Contamination α, β and γ Emitters c/s (b)	α, β and γ Emitters c/s (c)	α Emitters c/s (d)
1	Upper Level Hall	0.10	2	2	
2	2ª Cª Command	0.12	1.5	1.5	
3	2ª Cª Accommodations	0.06	2	2	
4	2ª Cª Accommodations	0.08	2	2	
5	Command and Services Cª	0.12	2	2	
6	Service Stairs	0.12	2	2	
7	Service Stairs Platform	0.12	2	2	
8	WC Hall	0.08	2	2	
9	WC	0.08	2	2	0.2
10	Officers Accommodations	0.10	2	2	0.2
11	Operations Area	0.10	2	2	0.2
12	Chaimites Parking	0.30	3		0.2
13	CCS Parking	0.26	2		0.2
14	First Aid Post	0.26	2		0.2
15	Fuel	0.24	2		0.2
16	Kitchen/Mess Hall	0.26	2		0.2

Ionization Chamber Victoreen 450P nº 1210
Contamination Monitor DS 501 nº 84 (natural background between 1 and 3 c/s)
Contamination Monitor DS 501 nº 112 (natural background between 1 and 3 c/s)
Contamination Monitor MIP 10 nº 7286 + SA70-2 nº194 (natural background 0.2 c/s)
c/s is the abbreviation of counts per second.

Table 9 – Results from external monitoring in the former Portuguese Barracks in Vitkovici (BiH), corrected for equipment efficiency. See picture 13 for the location of the measuring points.

Point Number	**Place**	**Dose Rate of External Radiation α Emitters μSv/h (a)**	**Surface Contamination**	
			α, β and γ Emitters counts/second (b)	**α Emitters counts/second (c)**
1	Barber	0.10	1.5	0.2
2	Storage	0.10	1.5	0.2
3	Hall	0.38	1.5	0.2
4	Accommodations	0.10	1.5	0.2
5	Accommodations	0.10	1.5	0.2
6	OPS Room	0.24	1.5	0.2
7	Camp HQ	0.12	1.5	0.2
8	Mess Hall	0.16	1.5	0.2

Ionization Chamber Victoreen 450P nº 1210
Contamination Monitor DS 501 nº 84 (natural background between 1 and 3 c/s)
Contamination Monitor MIP 10 nº 7286 + SA70-2 nº194 (natural background 0.2 c/s)

Table 10 – Results from external monitoring at Camp Dannevirke in Doboj (BiH), corrected for equipment efficiency. See picture 14 for the location of the measuring points.

Point Nº	**Place**	**Dose Rate of External Radiation**	**Surface Contamination**	
		α Emitters μSv/h (a)	**α, β and γ Emitters counts/second (b)**	**α Emitters counts/second (c)**
1	Main Gate	0.08	1	0.2
2		0.02	1	0.2
3		0.06	1	0.2
4		0.08	1	0.2
5		0.06	1.5	0.2
6		0.04	1	0.2
7		0.02	1	0.2
8	Weapon Storage	0.06	1	0.2
9		0.06	1	0.2
10		0.06	1	0.2
11		0.06	1	0.2
12		0.08	1	0.2
13		0.06	1	0.2
14	Parking	0.04	1	0.2
15		0.04	1.5	0.2
16		0.04	1.5	0.2
17	Parade	0.04	1	0.2
18		0.04	1	0.2
B	Kitchen/Mess Hall	0.08	1	0.2

Ionization Chamber Victoreen 450P nº 1210
Contamination Monitor DS 501 nº 84 (natural background between 1 and 3 c/s)
Contamination Monitor MIP 10 nº 7286 + SA70-2 nº194 (natural background 0.2 c/s)

Table 11 – Results from external monitoring at Camp Jussi in Doboj (BiH), corrected for equipment efficiency. See picture 15 for the location of the measuring points.

Point Number	Place	Dose Rate of External Radiation α Emitters μSv/h (a)	Surface Contamination α, β and γ Emitters counts/second (b)	Surface Contamination α Emitters counts/second (c)
1		0.04	1	0.2
2		0.08	1.5	0.2
3	Engineering	0.06	1	0.2
4	Cimic Centre	0.04	1	0.2
5		0.06	1	0.2
6		0.04	1	0.2
7	Bombarded Spot	0.08	1.5	0.2
8		0.06	1	0.2

Ionization Chamber Victoreen 450P nº 1210
Contamination Monitor DS 501 nº 84 (natural background between 1 and 2 c/s)
Contamination Monitor MIP 10 nº 7286 + SA70-2 nº194 (natural background 0.2 c/s)

Table 12 – Results from external contamination monitoring of the "1.ª CAT" at Camp Dannevirke, in Doboj (BiH), after a 10-day mission, corrected for equipment efficiency.

	Individual and vehicles Contamination	
	β and γ Emitters counts/second (a)	**α Emitters counts/second (b)**
81 Military Personnel	< 2	0.2
16 Tactical Vehicles	< 2	0.2

Contamination Monitor MIP 10 nº 7286 + SBG n.º 1442 (natural background between 1 and 2 c/s)
Contamination Monitor MIP 10 nº 801 + SA70-2 n.º 194 (natural background 0.2 c/s)

Table 13 – Results from external contamination monitoring of vehicles after a 10-day mission in Zenica (BiH), corrected for equipment efficiency.

	Vehicles Contamination	
	β and γ Emitters counts/second (a)	**α Emitters counts/second (b)**
10 Chaimites	< 2	0.2
9 All Road Vehicles	< 2	0.2
2 Iveco	< 2	0.2

Contamination Monitor MIP 10 nº 7286 + SBG n.º 1442 (natural background between 1 and 2 c/s)
Contamination Monitor MIP 10 nº 801 + SA70-2 n.º 194 (natural background 0.2 c/s)

Table 14 – Results from external monitoring in a variety of places around Lisbon corrected for equipment efficiency.

Location	**Dose Rate of External Radiation**	**Surface Contamination**	
	α Emitters μSv/h (a)	**α, β and γ Emitters counts/second (b)**	**α Emitters counts/second (c)**
Vila Franca de Xira Campino Statue	0.04	3	0.2
Alverca In front of the tax building	0.04	3	0.2
ITN DPRSN Garden	0.06	2	0.2
Sacavém Town Garden	0.02	3	0.2
Lisboa – Parque das Nações. Passeio Neptuno	0.04	2	0.2
Lisboa Airport	0.04	3	0.2

Ionization Chamber Victoreen 450P nº 1210
Contamination Monitor DS 501 nº 84 (natural background between 1 and 3 c/s)
Contamination Monitor MIP 10 nº 7286 + SA70-2 nº194 (natural background 0.2 c/s)

Table 15 - Radioactivity in food products from Kosovo determined by gamma spectrometry (Bq $kg^{-1} \pm 2\sigma$, fresh weight).

Sampling Site	Food Products	^{235}U	^{234}Th	^{234}Pa	^{226}Ra	^{210}Pb	^{137}Cs	^{40}K
KLINA	Bread	≤ 0.5	≤ 5.6	≤ 52	≤ 0.8	≤ 11	n.d.	33 ± 3
PRISTINA	Apples	≤ 0.3	≤ 2.9	≤ 23	≤ 0.3	≤ 6.0	n.d.	37 ± 2
	Kale	≤ 0.3	≤ 3.8	≤ 32	≤ 0.4	n.d.	n.d.	99 ± 9
	Onions	≤ 0.3	≤ 6.1	≤ 31	≤ 0.4	n.d.	n.d.	179 ± 14
	Fresh Cheese	≤ 0.2	≤ 1.9	≤ 19	≤ 0.3	≤ 3.6	n.d.	30 ± 2
	Potatoes	≤ 0.2	≤ 2.5	24 ± 5	0.34 ± 0.04	≤ 7.1	n.d.	176 ± 4
	Meat	≤ 0.3	≤ 4.0	37 ± 8	≤ 0.4	≤ 7.8	n.d.	103 ± 4
	Bread	≤ 0.3	4.2 ± 0.9	40 ± 9	≤ 0.5	≤ 10	n.d.	27 ± 2
BUDISAVIC	Honey	≤ 0.3	≤ 3.7	≤ 23	≤ 0.3	n.d.	0.3 ± 0.1	22 ± 3
	Fresh Cheese	≤ 1.4	19 ± 6	n.d.	≤ 2.4	≤ 42	n.d.	40 ± 8
PEC	Apples	≤ 0.2	≤ 3.3	≤ 22	≤ 0.3	n.d.	n.d.	38 ± 4
	Kale	≤ 0.2	4.6 ± 0.8	≤ 16	≤ 0.2	≤ 6.7	n.d.	45 ± 2
	Potatoes	≤ 0.3	≤ 3.9	≤ 27	≤ 0.4	n.d.	n.d.	136 ± 11
	Meat	≤ 0.2	≤ 3.2	≤ 23	≤ 0.3	n.d.	n.d.	108 ± 9
	Bread	≤ 0.5	≤ 5.3	42 ± 13	5.2 ± 1.0	≤ 11	n.d.	38 ± 2
	Fresh Cheese	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	41 ± 4
MITROVICA	Apples	≤ 0.1	6.1 ± 0.7	≤ 1.3	≤ 0.2	≤ 6.7	n.d.	33 ± 1
	Onions	≤ 0.3	4.1 ± 1.1	≤ 23	≤ 0.3	≤ 6.5	n.d.	85 ± 3
	Potatoes	≤ 0.1	≤ 2.0	≤ 23	≤ 0.2	≤ 6.1	n.d.	156 ± 3
	Kale	≤ 0.2	≤ 2.5	≤ 21	≤ 0.2	≤ 4.7	≤ 0.1	65 ± 2
	Meat	≤ 0.1	3.3 ± 0.7	n.d.	≤ 0.2	n.d.	0.07± 0.02	113 ± 3

n.d. (not detected)

Table 16 - Radioactivity in food products from Bosnia, determined by gamma spectrometry (Bq $kg^{-1} \pm 2\sigma$, fresh weight).

Sampling Site	Food Products	^{235}U	^{234}Th	^{234}Pa	^{226}Ra	^{210}Pb	^{137}Cs	^{40}K
VISOKO	Apples	≤ 0.1	≤ 2.0	≤ 13	≤ 0.2	≤ 5.5	n.d.	30 ± 1
	Apples	≤ 0.2	≤ 2.3	≤ 18	≤ 0.3	≤ 4.5	≤ 0.1	36 ± 2
	Kale	≤ 0.1	≤ 1.7	2.0 ± 0.5	≤ 0.2	≤ 4.8	≤ 0.1	54 ± 2
	Cherries	n.d.	n.d.	≤ 32	n.d.	n.d.	n.d.	85 ± 7
	Spinach	≤ 0.2	4.1 ± 0.8	≤ 31	≤ 0.4	≤ 8.5	≤ 0.2	107 ± 3
	Lettuce	n.d.	n.d.	n.d.	n.d.	n.d.	0.27 ± 0.16	100 ± 9
	Potatoes	≤ 0.2	≤ 2.4	≤ 26	0.40 ± 0.06	≤ 4.7	0.20 ± 0.06	137 ± 4
	Potatoes	≤ 0.2	≤ 3.0	≤ 25	≤ 0.3	n.d.	n.d.	132 ± 4
	Onions	≤ 0.2	≤ 0.7	n.d.	≤ 3.7	≤ 5.2	n.d.	59 ± 2
	Carottes	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	97 ± 8
	White Bread	≤ 0.6	≤ 7	≤ 54	≤ 0.9	≤ 14	≤ 0.4	36 ± 4
	Bread	≤ 0.4	≤ 5	≤ 40	≤ 0.5	n.d.	n.d.	41 ± 3
	Meat	≤ 1.3	≤ 14	n.d.	≤ 2.1	≤ 30	≤ 1.1	89 ± 21
	Cheese	≤ 0.3	≤ 3.5	≤ 24	≤ 0.4	≤ 8.7	≤ 0.2	54 ± 5

n.d. (not detected)

Table 16 – Continuation.

Sampling Site	Food products	^{235}U	^{234}Th	^{234}Pa	^{226}Ra	^{210}Pb	^{137}Cs	^{40}K
BREZA	Kale	≤ 0.1	≤ 2.0	≤ 21	≤ 2.5	≤ 2.4	≤ 0.1	57 ± 2
	Lettuce	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	94 ± 22
	Apples	≤ 0.2	≤ 2.5	≤ 24	≤ 0.3	≤ 4.7	n.d.	28 ± 2
	Potatoes	n.d.	n.d.	n.d.	n.d.	n.d.	≤ 0.3	185 ± 15
	Meat	≤ 0.1	≤ 1.9	≤ 19	≤ 0.2	≤ 4.9	≤ 0.1	101 ± 2
	Bread	≤ 0.1	≤ 1.6	≤ 15	≤ 0.2	n.d.	n.d.	20 ± 1
VISEGRAD	Onions	≤ 0.2	≤ 2.4	≤ 22	≤ 0.3	≤ 4.7	≤ 0.1	56 ± 2
	Kale	≤ 0.1	≤ 1.8	21 ± 6	≤ 0.2	≤ 4.8	≤ 0.1	70 ± 2
	Apples	≤ 0.2	≤ 2.4	≤ 21	≤ 0.3	≤ 4.8	≤ 0.1	33 ± 2
	Potatoes	≤ 0.2	≤ 3.2	≤ 24	≤ 0.3	n.d.	n.d.	153 ± 12
	Meat (Liver)	n.d.	n.d.	n.d.	n.d.	n.d.	≤ 0.2	107 ± 9
	Pork Meat	≤ 0.2	≤ 6.7	≤ 23	≤ 0.4	≤ 8.2	2.0 ± 0.2	130 ± 11
	Cheese	≤ 0.1	≤ 2.1	≤ 19	≤ 0.2	≤ 5.4	n.d.	≤ 2.6
	Bread	≤ 0.4	≤ 4.4	n.d.	≤ 0.6	≤ 8.3	n.d.	43 ± 3

n.d. (not detected)

Table 16 – Conclusion.

Sampling Site	Food products	^{235}U	^{234}Th	^{234}Pa	^{226}Ra	^{210}Pb	^{137}Cs	^{40}K
GRACANICA	Apples	≤ 0.1	2.2 ± 0.4	19 ± 5	≤ 0.2	≤ 4.9	≤ 0.1	34 ± 1
	Kale	1.3 ± 0.6	≤ 2.9	n.d.	≤ 0.4	≤ 5.7	n.d.	134 ± 4
	Cauliflower	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	109 ± 10
	Potatoes	≤ 0.2	≤ 2.4	≤ 21	≤ 0.3	≤ 4.7	n.d.	114 ± 4
	Broccoli	≤ 2.0	≤ 21	n.d.	≤ 3.1	n.d.	≤ 1.5	142 ± 20
	Lettuce	≤ 2.5	≤ 23	n.d.	≤ 3.3	≤ 60	≤ 1.6	107 ± 16
	Meat	≤ 1.9	≤ 18	n.d.	≤ 2.7	≤ 44	≤ 1.5	101 ± 15
	Meat	≤ 1.1	≤ 22	n.d.	≤ 2.3	≤ 31	≤ 1.1	138 ± 25
	Bread	≤ 0.4	≤ 5.1	≤ 33	≤ 0.5	≤ 13	≤ 0.2	43 ± 5
MOSTAR	Apples	≤ 0.2	≤ 1.9	≤ 16	≤ 0.2	≤ 5.2	0.2 ± 0.04	24 ± 1
	Kale	≤ 0.3	≤ 3.4	≤ 30	≤ 0.4	≤ 9.5	≤ 0.2	124 ± 3
	Lettuce	≤ 0.4	≤ 5.2	≤ 57	≤ 0.8	≤ 15	n.d.	92 ± 4
	Onions	≤ 0.2	≤ 2.5	≤ 19	≤ 0.3	n.d.	n.d.	65 ± 2
	Potatoes	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	65 ± 2
	Meat	≤ 0.3	≤ 3.2	≤ 24	≤ 0.4	≤ 6.2	≤ 0.2	180 ± 15
	Meat (Kidney)	≤ 0.3	≤ 10	≤ 30	≤ 0.5	≤ 11	0.5 ± 0.15	≤ 151
	Cheese	≤ 0.2	≤ 2.4	≤ 16	≤ 0.2	≤ 7.4	≤ 0.1	25 ± 1
	Bread	≤ 0.2	≤ 3.6	n.d.	≤ 0.5	n.d.	n.d.	38 ± 2

n.d. (not detected)

Table 17 – Radioactivity in food products from the Portuguese diet, determined by gamma spectrometry (Bq $kg^{-1} \pm 2\sigma$, fresh weight).

Sampling Site	Food Products	^{235}U	^{234}Th	^{234}Pa	^{226}Ra	^{210}Pb	^{137}Cs	^{40}K
BEIRA INTERIOR	Cabbage	≤ 0.4	≤ 5.3	≤ 41	≤ 0.6	≤ 15	≤ 0.3	116 ± 11
	Pork Meat	≤ 0.2	≤ 2.2	≤ 18	≤ 0.2	≤ 6.3	0.16 ± 0.03	68 ± 2
ALENTEJO	Oranges	≤ 0.1	≤ 2.1	≤ 17	≤ 0.2	≤ 5.3	≤ 0.1	55 ± 2
ALGARVE	Cabbage	≤ 0.2	≤ 3.2	≤ 28	≤ 0.4	≤ 8.3	≤ 0.2	35 ± 2
LISBOA (Supermarket)	Chicken	≤ 0.1	≤ 1.8	≤ 15	≤ 0.2	≤ 4.8	≤ 0.1	74 ± 2
	Beef Meat	≤ 0.3	≤ 7.4	≤ 36	≤ 0.3	≤ 9.1	≤ 0.2	129 ± 11
	Pork Meat	≤ 0.9	≤ 6.9	≤ 29	≤ 0.4	≤ 10	≤ 0.1	127 ± 10
	Apples	≤ 0.2	≤ 2.5	n.d.	≤ 0.4	≤ 4.8	n.d.	38 ± 2
	Pears	≤ 0.3	≤ 3.7	≤ 27	≤ 0.4	≤ 9.6	≤ 0.2	57 ± 6
	Bread	≤ 0.5	≤ 6.2	≤ 51	≤ 1.0	≤ 12	≤ 0.4	46 ± 4
	Carottes	≤ 0.2	≤ 6.5	≤ 26	≤ 0.4	≤ 9.0	≤ 0.2	122 ± 10
	Onions	≤ 0.1	≤ 1.8	≤ 17	≤ 0.3	n.d.	n.d.	37 ± 1
	Potatoes	≤ 0.2	n.d.	n.d.	≤ 0.3	n.d.	n.d.	112 ± 4
	Lettuce	≤ 0.2	≤ 3.1	n.d.	≤ 0.3	≤ 7.9	n.d.	114 ± 3
	Cabbage	≤ 0.1	≤ 2.2	n.d.	≤ 0.2	n.d.	0.14 ± 0.03	58 ± 2
	Eggs	≤ 0.2	≤ 2.7	≤ 19	0.3 ± 0.07	n.d.	n.d.	30 ± 2

n.d. (not detected)

Table 18 – Analysis of uranium, made by alpha spectrometry, in food products from Kosovo. Results expressed in fresh weight.

Designation	**^{238}U mBq kg^{-1} ± 1σ**	**^{235}U mBq kg^{-1} ± 1σ**	**^{234}U mBq kg^{-1} ± 1σ**	**U total mBq kg^{-1} ± 1σ**	**U total µg kg^{-1} ± 1σ**
Cheese (Pristina)	5.1 ± 0.6	1.0 ± 0.2	7.4 ± 0.7	**13.5 ± 1.5**	**0.42 ± 0.05**
Meat (Pec)	6.5 ± 0.7	0.4 ± 0.2	8.8 ± 0.8	**15.7 ± 1.7**	**0.53 ± 0.06**
Bread (Q. Klina)	7.9 ± 1.1	1.1 ± 0.4	11.0 ± 1.3	**20.0 ± 2.8**	**0.65 ± 0.09**
Onions (Pristina)	2.4 ± 0.4	0.1 ± 0.1	3.1 ± 0.5	**5.6 ± 1.0**	**0.19 ± 0.03**
Apples (Mitrovica)	31.8 ± 1.8	0.9 ± 0.3	38.2 ± 2.1	**70.9 ± 4.2**	**2.6 ± 0.2**
Potatoes (Pec)	7.8 ± 0.8	0.8 ± 0.2	8.8 ± 0.8	**17.4 ± 1.8**	**0.64 ± 0.06**
Cabbage (Mitrovica)	1.4 ± 0.3	0.1 ± 0.0	1.4 ± 0.3	**2.9 ± 0.6**	**0.11 ± 0.02**
Bread (Pec)	7.5 ± 0.8	0.1 ± 0.0	9.4 ± 0.9	**17.0 ± 1.7**	**0.60 ± 0.06**
Meat (Mitrovica)	2.2 ± 0.4	0.1 ± 0.1	2.2 ± 0.4	**4.5 ± 0.9**	**0.18 ± 0.04**

Table 19 – Uranium analysis made by alpha spectrometry, in food products from BiH. Results expressed in fresh weight.

Designation	**^{238}U mBq kg^{-1} ± 1σ**	**^{235}U mBq kg^{-1} ± 1σ**	**^{234}U mBq kg^{-1} ± 1σ**	**U total mBq kg^{-1} ± 1σ**	**U total µg kg^{-1} ± 1σ**
Meat (Gracanica)	1.9 ± 0.4	0.3 ± 0.1	1.6 ± 0.4	**3.8 ± 0.9**	**0.16 ± 0.04**
Bread (Mostar)	21.4 ± 1.9	0.4 ± 0.3	11.9 ± 1.4	**33.7 ± 2.6**	**1.3 ± 0.1***
Bread (Breza)	58.0 ± 2.8	1.6± 0.3	14.1 ± 1.1	**73.7 ± 4.2**	**4.7 ± 0.3***
Bread (Visegrado)	24.3 ± 1.8	1.2 ± 0.4	12.9 1.3	**38.4 ± 2.6**	**1.5 ± 0.1**
Liver (Visegrado)	3.7 ± 0.6	0.4 ± 0.1	3.1 ± 0.6	**7.2 ± 1.3**	**0.30 ± 0.05**
Meat (Visoko)	3.5 ± 0.4	0.1 ± 0.1	2.1 ± 0.4	**5.7 ± 0.9**	**0.28 ± 0.04**
Potatoes (Visoko)	3.4 ± 0.5	0.6 ± 0.2	4.2 ± 0.5	**8.2 ± 1.2**	**0.28 ± 0.04**
Cabbage (Mostar)	7.3 ± 0.9	0.1 ± 0.1	10.0 ± 1.0	**17.4 ± 2.0**	**0.59 ± 0.07**
Onions (Mostar)	4.0 ± 0.4	0.4 ± 0.1	3.9 ± 0.3	**8.3 ± 0.8**	**0.33 ± 0.03**
Apples (Breza)	2.8 ± 0.2	0.3 ± 0.1	2.7 ± 0.2	**5.8 ± 0.5**	**0.23 ± 0.02**

*possible presence of depleted uranium.

Table 20 – Radioactivity in soils from Kosovo, determined by gamma spectrometry (Bq $kg^{-1} \pm 2\sigma$, dry weight).

Sampling Site	Sampling Point	^{235}U	^{234}Th	^{234}Pa	^{226}Ra	^{210}Pb	^{137}Cs	^{40}K
2 (PEC)	PEC 7	5.7 ± 0.6	≤ 20	n.d.	29 ± 1	n.d.	94 ± 3	496 ± 18
	PEC 8	6.6 ± 0.8	66 ± 8	n.d.	24 ± 1	≤ 73	113 ± 6	494 ± 46
3 (BANJA)		8.4 ± 0.9	≤ 25	n.d.	47 ± 2	n.d.	36 ± 3	342 ± 32
4 (DECANI)		4.4 ± 1.5	≤ 44	n.d.	21 ± 3	≤ 53	92 ± 9	454 ± 53
5 (SKIVJAN)		n.d.	n.d.	n.d.	19 ± 3	n.d.	23 ± 3	424 ± 51
6 (DJAKOVICA)	Parade	64 ± 2	2119 ± 67	7204 ± 213	8.4 ± 1.1	n.d.	75 ± 3	218 ± 24
6 (DJAKOVICA)		2.8 ± 1.2	≤ 44	n.d.	19 ± 3	≤ 58	60 ± 6	444 ± 51
7 (DJAKOVICA)		n.d.	n.d.	n.d.	≤ 11	n.d.	15 ± 4	542 ± 104
8 (BERKOVO)		≤ 2	≤ 39	n.d.	16 ± 2	≤ 47	43 ± 5	447 ± 51
9 (BUDISAVCI)		6.4 ± 0.7	21 ± 2	n.d.	26 ± 1	214 ± 20	115 ± 6	472 ± 41
10 (KRUSEVO)		3.9 ± 0.6	53 ± 5	n.d.	18 ± 1	≤ 61	38 ± 1	809 ± 25
11 (JAGODA)	Topers	≤ 1.6	70 ± 3	205 ± 52	17 ± 1	≤ 48	105 ± 3	430 ± 16
	0-5 cm	n.d	54 ± 5	n.d.	21 ± 3	83 ± 23	32 ± 2	610 ± 60
	5-10 cm	≤ 5.8	50 ± 10	n.d.	17 ± 2	≤ 48	126 ± 5	487 ± 65
	10-15 cm	5.4 ± 1.6	39 ± 5	n.d.	22 ± 2	≤ 82	69 ± 3	350 ± 55
		≤ 3.9	43 ± 7	n.d.	25 ± 3	n.d.	28 ± 2	551 ± 56
12 (River BELI DRIM)		≤ 2.3	33 ± 5	n.d.	26 ± 1	n.d.	93 ± 2	250 ± 25
13		3.1 ± 0.5	35 ± 4	n.d.	22 ± 1	≤ 28	21 ± 1	455 ± 18
15 (Mines Volujak)		7.6 ± 0.5	85 ± 5	175 ± 32	49 ± 1	≤ 43	1.6 ± 0.3	443 ± 13
17 (DUZ)		3.5 ± 1.1	≤ 32	n.d.	12 ± 2	≤ 41	145 ± 13	200 ± 29
18 (VOLUJAK)		≤ 1.4	≤ 35	n.d.	≤ 3.0	≤ 50	6.3 ± 1.0	55 ± 19
19 (SVRHE)		2.8 ± 0.5	≤ 14	n.d.	18 ± 1	≤ 36	29 ± 1	250 ± 12
21 (STARIKA)		≤ 3.8	≤ 55	n.d.	14 ± 1	≤ 27	9.1 ± 1.2	546 ± 47
22 (JOSANIKA)		≤ 2.6	58 ± 7	n.d.	5.1 ± 0.8	≤ 56	34 ± 2	248 ± 27
23 (BICA)		≤ 3.8	≤ 46	n.d.	12 ± 1	n.d.	38 ± 2	364 ± 28
24 (RENOVAC)		5.0 ± 1.4	≤ 40	n.d.	24 ± 2	≤ 63	8.5 ± 1.2	370 ± 39
25 (RENOVAC)		n.d.	n.d.	n.d.	n.d.	n.d.	27 ± 4	571 ± 112

n.d. (not detected)

Table 20 – Conclusion.

Sampling Site	Sampling Point	^{235}U	^{234}Th	^{234}Pa	^{226}Ra	^{210}Pb	^{137}Cs	^{40}K
27 (KLINA)		≤ 4.6	49 ± 8	n.d.	7.8 ± 2.0	n.d.	25 ± 2	450 ± 51
28 (KLINA)		≤ 1.0	≤ 11	n.d.	8.4 ± 0.5	≤ 19	61 ± 2	186 ± 9
29 (PRLINA)		4.7 ± 0.7	50 ± 6	n.d.	27 ± 1	≤ 51	21 ± 1	558 ± 48
30 (KIJEVO)		≤ 1.8	n.d.	n.d.	21 ± 2	≤ 62	105 ± 10	588 ± 51
31 (NEGROVCE)		3.5 ± 0.9	94 ± 9	n.d.	39 ± 1	≤ 59	35 ± 2	432 ± 38
32 (PRISTINA)		3.1 ± 0.4	35 ± 4	n.d.	≤ 2.2	≤ 39	83 ± 2	418 ± 15
33 (PRISTINA)		≤ 3.6	≤ 39	n.d.	18 ± 2	≤ 67	27 ± 2	413 ± 37
36 (VUSTRIN)		≤ 3.0	153 ± 12	432 ± 85	47 ± 2	≤ 72	56 ± 3	599 ± 53
39 (MITROVICA)		n.d.	n.d.	n.d.	17 ± 5	n.d.	50 ± 5	661 ± 111
40 (RUDNICK)		3.9 ± 1.1	≤ 35	n.d.	56 ± 2	≤ 61	68 ± 3	383 ± 30
41 (DURAKOVAC)		≤ 4.3	≤ 56	n.d.	21 ± 3	≤ 47	47 ± 5	341 ± 42
42 (Lake RADONIC)		4.2 ± 1.4	≤ 36	n.d.	26 ± 3	≤ 37	8.1 ± 1.6	178 ± 28
43 (Lake RADONIC)	Zone of bullet impact Bullet hole Fragments of metal Soil Soil near the dam	≤ 7.2 81 ± 7 ≤ 2.1 6.0 ± 1.0 ≤ 12.1	n.d. 4441 ± 398 ≤ 19 ≤ 32 230 ± 36	n.d. 8493 ± 820 n.d. n.d. n.d.	≤ 14 12 ± 2 11 ± 1 16 ± 1 ≤ 24	n.d. ≤ 56 ≤ 31 n.d. 260 ± 67	27 ± 5 8.4 ± 1.5 n.d. 246 ± 13 43 ± 4	≤ 171 124 ± 21 ≤ 48 268± 29 ≤ 266
44 (PRIZREN)		4.3 ± 1.2	59 ± 11	n.d.	39 ± 2	≤ 68	60 ± 2	419 ± 30
45 (KRAJK)		≤ 1.8	≤ 42	n.d.	16 ± 2	≤ 22	6.5 ± 1.6	413 ± 46
46 (ZUR)		7.3 ± 1.0	45 ± 9	n.d.	40 ± 1	n.d.	106 ± 6	470 ± 43
48 (SUVAREKA)		5.1 ± 0.8	≤ 28	n.d.	30 ± 1	≤ 60	17 ± 1	565 ± 50
49 (BELIN)		3.7 ± 0.6	42 ± 4	n.d.	23 ± 1	≤ 34	56 ± 2	415 ± 22
50 (LIPJAN)		≤ 2.5	≤ 43	n.d.	20 ± 1	n.d.	17 ± 1	502 ± 31

n.d. (not detected)

Table 21 – Radioactivity in soils from Bosnia-Herzegovina, determined by gamma spectrometry (Bq $kg^{-1} \pm 2\sigma$, dry weight).

Sampling Site	^{235}U	^{234}Th	^{234}Pa	^{226}Ra	^{210}Pb	^{137}Cs	^{40}K
2 (BUCI)	6.2 ± 0.6	47 ± 5	n.d.	40 ± 4	n.d.	138 ± 4	730 ± 22
3 (BREZA)	≤ 2.7	≤ 26	n.d.	25 ± 1	≤ 66	166 ± 9	434 ± 40
4c (VISOKO(Helip.))	n.d.	n.d.	n.d.	24 ± 3	n.d.	62 ± 6	762 ± 86
5 (ROGATICA)	≤ 4.3	≤ 45	n.d.	11 ± 2	≤ 38	32 ± 4	326 ± 40
6 (VITKOVICI)	11 ± 1	40 ± 11	n.d.	69 ± 2	n.d.	92 ± 5	427 ± 41
7 (VITKOVICI)	≤ 6.5	n.d.	n.d.	33 ± 3	≤ 83	27 ± 3	887 ± 77
8 (MILJENO)	≤ 4.0	≤ 83	n.d.	33 ± 4	≤ 89	49 ± 5	874 ± 93
9 (GORADZE)	5.8 ± 0.8	36 ± 6	n.d.	39 ± 2	≤ 57	3.1 ± 0.6	608 ± 52
10 (JABUKA)	6.1 ± 0.6	60 ± 4	n.d.	27 ± 1	≤ 51	17 ± 1	494 ± 18
11 (PRACA)	6.5 ± 0.9	50 ± 7	n.d.	34 ± 1	≤ 67	62 ± 3	748 ± 64
12 (USTRIPRACA)	6.8 ± 0.9	≤ 29	n.d.	30 ± 2	n.d.	9.8 ± 1.0	687 ± 59
14 a (VISEGRAD)	≤ 4.2	46 ± 11	n.d.	10 ± 1	≤ 75	46 ± 2	619 ± 57
15 (ZHARID)	≤ 5.5	n.d.	n.d.	≤ 8.0	n.d.	39 ± 2	557 ± 53
16 (DOBOJ)	4.9 ± 0.9	32 ± 5	n.d.	23 ± 1	≤ 54	43 ± 3	250 ± 26
17 (DOBOJ)	4.1 ± 1.0	68 ± 9	n.d.	24 ± 1	n.d.	117 ± 6	384 ± 37
18 (DOBOJ)	6.8 ± 1.3	≤ 51	n.d.	≤ 6.7	n.d.	≤ 3.6	740 ± 41

n.d. (not detected)

Table 21 – Conclusion.

Sampling Site	^{235}U	^{234}Th	^{234}Pa	^{226}Ra	^{210}Pb	^{137}Cs	^{40}K
19 (GRACANICA)	≤ 5.6	≤ 51	n.d.	19 ± 3	≤ 47	93 ± 9	394 ± 49
20 (ZAVIDOVICI)	≤ 4.2	37 ± 4	n.d.	18 ± 2	≤ 72	24 ± 2	511 ± 58
21 (ZENICA)	3.6 ± 1.7	≤ 45	n.d.	24 ± 3	≤ 35	57 ± 6	386 ± 50
22 (ZETRA)	7.4 ± 0.9	36 ± 8	447 ± 79	≤ 4.6	n.d.	40 ± 2	633 ± 56
23 (TITO BARRACKS)	n.d.	n.d.	n.d.	30 ± 4	n.d.	105 ± 10	637 ± 69
24 (ILIDZÁ)	5.1 ± 0.5	55 ± 5	215 ± 52	30 ± 1	n.d.	20 ± 1	598 ± 19
25 (Road to PALE)	≤ 2.5	≤ 47	n.d.	22 ± 3	≤ 43	39 ± 4	513 ± 57
26 (Road to PALE)	≤ 5.3	≤ 43	n.d.	36 ± 4	≤ 49	72 ± 7	591 ± 64
27 (BUTMIR)	≤ 2.9	≤ 31	n.d.	33 ± 1	n.d.	68 ± 4	664 ± 58
29 (HADZICI)	n.d.	n.d.	n.d.	34 ± 4	n.d.	232 ± 21	987 ± 102
30 (HRASNICA)	2.4 ± 0.5	62 ± 6	n.d.	39 ± 2	n.d.	53 ± 2	614 ± 23
31 (HADZICI)	≤ 3.3	≤ 31	n.d.	17 ± 2	≤ 35	103 ± 10	234 ± 34
32 (HADZICI)	22 ± 2	221 ± 15	n.d.	22 ± 1	≤ 62	30 ± 2	333 ± 30
33 (HADZICI)	5.6 ± 1.2	43 ± 4	n.d.	24 ± 2	≤ 64	130 ± 4.4	258 ± 48
34 (BRADINA)	6.1 ± 1.1	39 ± 11	n.d.	18 ± 1	n.d.	119 ± 6	141 ± 22
35 (OSTROZAC)	≤ 8.3	≤ 56	n.d.	41 ± 4	n.d.	33 ± 4	729 ± 77
36 (MOSTAR)	≤ 2.9	≤ 92	n.d.	42 ± 4	≤ 98.	161 ± 12	468 ± 46

n.d. (not detected)

Table 22 – Radioactivity in soils from a variety of regions of Portugal and the Azores, determined by gamma spectrometry (Bq $kg^{-1} \pm 2\sigma$, dry weight).

Sampling	**Sampling**		**^{235}U**	**^{234}Th**	**^{234}Pa**	**^{226}Ra**	**^{210}Pb**	**^{137}Cs**	**^{40}K**
Site	**Year**	**Point**							
SACAVÉM	2001		≤ 2.8	≤ 47	n.d.	36 ± 4	≤ 27	≤ 1.7	686 ± 72
SESIMBRA	2001		≤ 1.7	≤ 49	n.d.	13 ± 2	≤ 36	7.9 ± 1.8	780 ± 78
LOULÉ	2001		≤ 3.3	≤ 47	n.d.	14 ± 2	≤ 44	≤ 2.6	433 ± 51
NELAS	2001		5.8 ± 2.5	60 ± 12	n.d.	107 ± 2	n.d.	47 ± 2	1479 ± 34
TORRES VEDRAS	2001		≤ 1.2	47 ± 3	n.d.	24 ± 0.9	≤ 26	1.3 ± 0.3	700 ± 22
	2000	23B	11 ± 1	96 ± 8	n.d	45 ± 1	≤ 35	2.1 ± 0.4	1451 ± 39
	2000	24B	8.9 ± 0.9	113 ± 7	n.d.	42 ± 1	55 ± 13	31 ± 1	1396 ± 41
AÇORES	2000	27B	7.5 ± 1.9	152 ± 9	n.d	5.3 ± 0.1	≤ 68	15 ± 1	1205 ± 30
	2000	29B	10 ± 1	90 ± 5	n.d.	43 ± 1	≤ 33	15 ± 1	872 ± 28
	2000	32B	4.5 ± 0.6	95 ± 7	n.d.	19 ± 1	59 ± 14	29 ± 1	646 ± 26
	2000	39C	7.6 ± 0.7	99 ± 8	n.d.	29 ± 1	≤ 61	2.9 ± 0.5	46 ± 10

n.d. (not detected)

Table 23 – Plutonium and uranium in soil samples from Kosovo (granulometric fraction < 250 μm; results expressed in dry weight).

Sampling Site	$^{239+240}$Pu mBq kg^{-1} ±1σ	^{238}U Bq kg^{-1} ± 1σ	^{235}U Bq kg^{-1} ± 1σ	^{234}U Bq kg^{-1} ± 1σ	U total Bq kg^{-1} ± 1σ	U total mg kg^{-1} ± 1σ	Ratio ^{235}U/^{238}U
Est.6	-	4667 ± 214	72 ± 9	595 ± 32	**5334 ± 255**	**376 ± 18**	0.015 ± 0.002
Est.9	-	26 ± 1	0.8 ± 0.2	26 ± 1	**53 ± 3**	**2.1 ± 0.1**	0.032 ± 0.008
Est.10	-	20 ± 1	1.1 ± 0.2	17 ± 1	**38 ± 2**	**1.6 ± 0.1**	0.058 ± 0.009
Est.12	-	9 ± 1	0.5 ± 0.1	10 ± 1	**19 ± 1**	**0.70 ± 0.05**	0.054 ± 0.016
Est.13	-	26 ± 2	1.2 ± 0.3	26 ± 2	**53 ± 3**	**2.1 ± 0.1**	0.048 ± 0.011
Est.15	-	71 ± 4	2.3 ± 0.5	71 ± 4	**144 ± 8**	**5.7 ± 0.3**	0.032 ± 0.007
Est.17	-	14 ± 1	0.8 ± 0.2	15 ± 1	**30 ± 2**	**1.13 ± 0.08**	0.057 ± 0.015
Est.18	-	8 ± 1	0.8 ± 0.1	7 ± 1	**16 ± 1**	**0.63 ± 0.05**	0.108 ± 0.040
Est.19	-	18 ± 1	0.7 ± 0.2	18 ± 1	**37 ± 2**	**1.46 ± 0.09**	0.039 ± 0.012
Est.20	-	27 ± 2	1.0 ± 0.3	21 ± 2	**49 ± 4**	**2.2 ± 0.2**	0.037 ± 0.012
Est.21	-	22 ± 1	1.3 ± 0.3	21 ± 1	**44 ± 2**	**1.8 ±0.1**	0.060 ± 0.014
Est.22	-	11 ± 1	1.1 ± 0.2	10 ± 1	**22 ± 2**	**0.90 ± 0.09**	0.104 ± 0.023
Est.23	-	15 ± 1	0.6 ± 0.2	12 ± 1	**28 ± 2**	**1.21 ± 0.09**	0.044 ± 0.015
Est.24	-	23 ± 2	1.4 ± 0.4	18 ± 1	**42 ± 3**	**1.9 ± 0.2**	0.063 ± 0.019
Est.28	<55	14 ± 1	0.9 ± 0.2	14 ± 1	**29 ± 2**	**1.18 ± 0.07**	0.062 ± 0.012
Est.29	-	34 ± 2	1.9 ± 0.4	28 ± 2	**64 ± 4**	**2.7 ± 0.2**	0.056 ± 0.011
Est.33	99 ±44	23 ± 1	1.3 ± 0.2	20 ± 1	**44 ± 2**	**1.84 ± 0.08**	0.060 ± 0.011
Est.42	-	19 ± 1	0.9 ± 0.1	19 ± 1	**39 ± 2**	**1.55 ± 0.07**	0.048 ± 0.007
Est.43	86 ± 21	87 ± 4	2,1 ± 0,3	20 ± 1	**109 ± 5**	**7.0 ± 0.3**	0.014 ± 0.009
Est.46	-	38 ± 2	1.2 ± 0.3	37 ± 2	**76 ± 4**	**3.1 ± 0.2**	0.032 ± 0.007

Table 24 – Plutonium e uranium in soil samples from Bosnia-Herzegovina (granulometric fraction < 250 μm; results expressed in dry weight).

Sampling Site	$^{239+240}$Pu mBq kg^{-1} ± 1σ	^{238}U Bq kg^{-1} ± 1σ	^{235}U Bq kg^{-1} ± 1σ	^{234}U Bq kg^{-1} ± 1σ	U total Bq kg^{-1} ± 1σ	U total mg kg^{-1} ± 1σ	Ratio ^{235}U/^{238}U
Est.2	-	25 ± 1	0.9 ± 0.2	26 ± 1	**52 ± 2**	**2.0 ± 0.1**	0.036 ± 0.007
Est.4	112 ± 33	25 ± 2	1.5 ± 0.3	24 ± 1	**51 ± 3**	**2.0 ± 0.1**	0.060 ± 0.011
Est.5	-	13 ± 1	0.6 ± 0.2	11 ± 1	**25 ±2**	**1.02 ± 0.07**	0.048 ± 0.016
Est.6	55 ± 32	56 ± 3	3.5 ± 0.4	56 ± 3	**116 ± 6**	**4.5 ± 0.2**	0.063 ± 0.009
Est.9	547 ± 55	34 ± 2	1.5 ± 0.2	34 ± 2	**70 ± 3**	**2.8 ± 0.1**	0.044 ± 0.006
Est.11	387 ± 62	30 ± 2	1.3 ± 0.2	29 ± 2	**60 ± 3**	**2.4 ± 0.1**	0.044 ± 0.007
Est.12	-	36 ± 2	1.5 ± 0.3	32 ± 2	**70 ± 4**	**2.9 ± 0.2**	0.042 ± 0.008
Est.21	-	37 ± 2	1.4 ± 0.2	32 ± 2	**70 ± 4**	**3.0 ± 0.1**	0.039 ± 0.007
Est.22	-	32 ± 2	1.6 ± 0.2	33 ± 2	**67 ± 3**	**2.6 ± 0.1**	0.051 ± 0.008
Est.25	-	25 ± 2	1.4 ± 0.3	26 ± 2	**52± 4**	**2.0 ± 0.2**	0.056 ± 0.014
EST.29	-	43 ± 2	1.4 ± 0.3	39 ± 2	**83 ± 4**	**3.4 ± 0.2**	0.032 ± 0.006
Est.30	-	30 ± 2	2.0 ± 0.3	33 ± 2	**65 ± 3**	**2.5 ± 0.1**	0.066 ± 0.010
Est.34	-	21 ± 1	0.8 ± 0.2	23 ± 1	**45 ± 2**	**1.7± 0.1**	0.039 ± 0.011
Est.36	-	29 ± 2	2.1 ± 0.4	27 ± 2	**58 ± 4**	**2.4 ± 0.2**	0.073 ± 0.014

Table 25 – Uranium in water samples from Kosovo.

Sample Site	^{238}U mBq L^{-1} ± 1σ	^{235}U mBq L^{-1} ± 1σ	^{234}U mBq L^{-1} ± 1σ	U total mBq L^{-1} ± 1σ	U total μg L^{-1} ± 1σ	Ratio $^{235}U/^{238}U$
Pec (PSP) surface water	2.4 ± 0.2	0.1 ± 0.0	3.6 ± 0.2	**6.2 ± 0.3**	**0.20 ± 0.01**	0.074 ± 0.016
Mitrovica	3.1 ± 0.2	0.2 ± 0.0	4.6 ± 0.2	**7.9± 0.4**	**0.25 ± 0.01**	0.071 ± 0.015
Klina (QG)	7.4 ± 0.3	0.4 ± 0.1	19.6 ± 0.8	**27.4 ± 1.2**	**0.60 ± 0.03**	0.050 ± 0.007
Pristina (surface water)	9.4 ± 0.4	0.4 ± 0.1	14.1 ± 0.6	**23.9 ± 1.1**	**0.76 ± 0.04**	0.046 ± 0.008
River Beli Drim (bridge)	4.6 ± 0.2	0.2 ± 0.0	9.9 ± 0.4	**14.7 ± 0.6**	**0.37 ± 0.002**	0.049 ± 0.006
River Beli Drim (Slozainovo)	7.8 ± 0.4	0.4 ± 0.1	10.6 ± 0.4	**18.8 ± 0.9**	**0.63 ± 0.03**	0.053 ± 0.007
Lake Radonic	8.7 ± 0.4	0.4 ± 0.1	10.6 ± 0.5	**19.7 ± 1.0**	**0.70 ± 0.04**	0.050 ± 0.008
Prizen	2.5 ± 0.2	0.1 ± 0.0	4.4 ± 0.2	**7.0 ± 0.4**	**0.20 ± 0.01**	0.062 ± 0.013
Djakovica	8.7 ± 0.4	0.4 ± 0.1	10.0 ± 0.4	**19.1 ± 0.9**	**0.70 ± 0.03**	0.043 ± 0.007
MEAN N = 9	**6.1**	**0.3**	**9.7**	**16.1**	**0.49**	
Standard deviation	**2.9**	**0.1**	**5.1**	**7.6**	**0.23**	
Min - Max	**2.4 – 9.4**	**0.1 – 0.4**	**3.6 – 19.6**	**6.2 – 27.4**	**0.20 – 0.76**	

Table 26 – Uranium in water samples from Bosnia-Herzegovina.

Sampling Site	**^{238}U mBq L^{-1} ± 1σ**	**^{235}U mBq L^{-1} ± 1σ**	**^{234}U mBq L^{-1} ± 1σ**	**U total mBq L^{-1} ± 1σ**	**U total μg L^{-1} ± 1σ**	**Ratio $^{235}U/^{238}U$**
Visoko (Police headquarters)	5.6 ± 0.3	0.3 ± 0.0	7.4 ± 0.3	**13.3 ± 0.6**	**0.45 ± 0.02**	0.054 ± 0.008
Mostar (surface water)	4.3 ± 0.2	0.2 ± 0.0	6.6 ± 0.3	**11.1 ± 0.5**	**0.35 ± 0.02**	0.058 ± 0.008
Gracanica (surface water)	14.8 ± 0.6	0.8 ± 0.1	14.5 ± 0.6	**30.1 ± 1.3**	**1.20 ± 0.05**	0.053 ± 0.005
Visegrado (surface water)	4.9 ± 0.2	0.2 ± 0.0	6.0 ± 0.3	**11.1 ± 0.5**	**0.40 ± 0.02**	0.049 ± 0.009
Breza (surface water)	3.1 ± 0.2	0.2 ± 0.0	6.5 ± 0.3	**9.8 ± 0.5**	**0.25 ± 0.01**	0.066 ± 0. 12
Sarajevo (surface water)	3.5 ± 0.3	0.1 ± 0.0	5.1 ± 0.3	**8.7 ± 0.4**	**0.28 ± 0.02**	0.042 ± 0.011
Goradze (surface water)	1.9 ± 0.1	0.1 ± 0.0	2.7 ± 0.1	**4.7 ± 0.2**	**0.15 ± 0.01**	0.055 ± 0.008
River Bosna (spring water)	0.79 ± 0.01	0.05 ± 0.00	1.7 ± 0.1	**2.6 ± 0.1**	**0.064 ± 0.004**	0.006 ± 0.01
Mean n = 8	**4.9**	**0.2**	**6.3**	**11.4**	**0.4**	
Standard deviation	**4.3**	**0.2**	**3.8**	**8.3**	**0.3**	
MIN - MAX	**0.79 – 14.8**	**0.05 – 0.8**	**1.72 – 14.5**	**2.6 – 30.1**	**0.064 – 1.2**	

Table 27 – Uranium in water from Portugal.

Sampling Site	^{238}U mBq L^{-1} ± 1σ	^{235}U mBq L^{-1} ± 1σ	^{234}U mBq L^{-1} ± 1σ	U total mBq L^{-1} ± 1σ	U total μg L^{-1} ± 1σ	Ratio $^{235}U/^{238}U$
Surface water Lisboa	7.3 ± 0.4	0.5 ± 0.1	8.2 ± 0.4	**16.0 ± 0.9**	**0.59 ± 0.03**	0.070 ± 0.010
Spring water Pedrogão G.	1.1 ± 0.1	0.1 ± 0.0	2.7 ± 0.1	**3.9 ± 0.2**	**0.090 ± 0.004**	0.092 ± 0.13
Surface water Pedrogão G.	2.0 ± 0.1	0.1 ± 0.0	2.3 ± 0.1	**4.4 ± 0.2**	**0.162 ± 0.008**	0.065 ± 0.008
Surface water Vila de Rei	0.9 ± 0.1	0.05 ± 0.00	2.3 ± 0.1	**3.2 ± 0.2**	**0.072 ± 0.003**	0.060 ± 0.010
River water Tejo B. Fratel	31.5 ± 1.5	1.3 ± 0.1	33.5 ± 1.6	**66.5 ± 3.2**	**2.55 ± 0.22**	0.041 ± 0.05
River water Tejo Chamusca	15.9 ± 0.7	1.2 ± 0.1	16.7 ± 0.7	**33.8 ± 1.5**	**1.29 ± 0.06**	0.075 ± 0.007
River water Tejo Valada	6.1 ± 0.3	0.3 ± 0.1	8.9 ± 0.5	**15.3 ± 0.8**	**0.49 ± 0.03**	0.056 ± 0.009
River water Zêzere, C. Bode	0.31 ± 0.02	0.02 ± 0.00	0.31 ± 0. 02	**0.62 ± 0.04**	**0.025 ± 0.001**	0.072 ± 0.018
Mean n = 8	**8.1**	**0.41**	**9.4**	**18.0**	**0.66**	
Standard deviation	**10.8**	**0.5**	**11.1**	**22.4**	**0.87**	
Min - Max	**0.31 – 31.5**	**0.02 – 1.3**	**0.31 – 33.5**	**0.62 – 66.5**	**0.025 – 2.55**	

Table 28 – Analysis of aerosol samples (filters) by gamma spectrometry.
PTS = total particles in suspension.

	Sampling Site	PTS ($\mu g\ m^{-3}$)	^{7}Be ($mBq\ m^{-3}$)	^{7}Be ($mBq\ mg^{-1}$)	^{210}Pb ($mBq\ m^{-3}$)	^{210}Pb ($mBq\ mg^{-1}$)	^{137}Cs ($mBq\ m^{-3}$)	^{137}Cs ($mBq\ mg^{-1}$)
Kosovo	**1** (Klina)	92	5.7 ± 0.3	62 ± 4	1.8 ± 0.3	19 ± 4	≤ 0.04	≤ 0.42
	9 (Budisavci)	45	6.7 ± 0.4	151 ± 8	2.0 ± 0.4	44 ± 8	n.d.	n.d.
	33 (Pristina)	52	5.9 ± 0.3	113 ± 6	1.0 ± 0.2	18 ± 4	n.d.	n.d.
Bosnia	**1** (Visoko - exterior)	93	8.7 ± 0.5	94 ± 5	1.5 ± 0.4	16 ± 4	n.d.	n.d.
	5 (Rogatica)	58	5.0 ± 0.3	86 ± 5	0.8 ± 0.2	14 ± 4	0.04 ± 0.01	0.68 ± 0.19
	1 (Visoko - interior)	121	5.4 ± 0.3	44 ± 2	0.8 ± 0.2	6.8 ± 1.3	0.03 ± 0.01	0.27 ± 0.07
	Portuguese Emb. (Sarajevo)	43	3.7 ± 0.3	84 ± 6	≤ 0.5	≤ 12	≤ 0.03	≤ 0.64
	27 (Sarajevo)	86	4.0 ± 0.3	47 ± 3	0.9 ± 0.2	11 ± 2	n.d.	n.d.
	31 (Hadzici)	34	5.9 ± 0.3	172 ± 9	1.0 ± 0.2	28 ± 5	n.d.	n.d.

Detection Limits:
^{241}Am - 0.08 $mBq\ m^{-3}$ / 0.6 $mBq\ mg^{-1}$
^{235}U - 0.05 $mBq\ m^{-3}$ / 0.4 $mBq\ mg^{-1}$

Table 29 – Uranium analysis in aerosol samples by alpha spectrometry. Results expressed in activity per volume (μBq m^{-3}) and in activity per unit of weight of particles in suspension (Bq kg^{-1}).

Kosovo

concentration in activity

Designation	^{238}U μBq m^{-3} ± 1σ	^{235}U μBq m^{-3}± 1σ	^{234}U μBq m^{-3}± 1σ	U total μBq m^{-3}± 1σ	U total ng m^{-3}± 1σ
KLINA (QG)	2.2 ± 0.1	0.2 ± 0.0	2.2 ± 0.1	**4.6 ± 0.2**	**0.182± 0.009**
Monastery of Budisavci	7.2 ± 0.4	2.1 ± 0.3	10.5 ± 0.6	**19.8 ± 1.0**	**0.782 ± 0.038**
Pristina (KFOR Headquarters)	3.0 ± 0.2	0.2 ± 0.0	2.8 ± 0.2	**6.0 ± 0.3**	**0.237 ± 0.013**

concentration in weight

Designation	^{238}U Bq kg^{-1} ± 1σ	^{235}U Bq kg^{-1} ± 1σ	^{234}U Bq kg^{-1} ± 1σ	U total Bq kg^{-1} ± 1σ	U total mg kg^{-1}± 1σ
KLINA (HQ)	24 ± 2	1.8 ± 0.3	24 ± 2	**50 ± 3**	**2.0± 0.1**
Monastery of Budisavci	159 ± 10	52 ± 6	232 ± 13	**443 ± 29**	**13.4 ± 0.9**
Pristina (KFOR Headquarters)	58 ± 4	4.3 ± 0.9	53 ± 4	**115 ± 6**	**4.7 ± 0.4**

Bosnia

concentration in activity

Designation	^{238}U μBq m^{-3} ± 1σ	^{235}U μBq m^{-3}± 1σ	^{234}U μBq m^{-3}± 1σ	U total μBq m^{-3}± 1σ	U total ng m^{-3}± 1σ
ROGATICA (PC ITALIAN)	0.78 ± 0.07	0.07 ± 0.00	0.89 ± 0.07	**1.74 ± 0.12**	**0.068± 0.005**
Visoko (HQ)	2.3 ± 0.2	0.4 ± 0.1	2.8 ± 0.2	**5.5 ± 0.4**	**0.217 ± 0.014**
Sarajevo (Port. Embassy)	6.3 ± 0.4	0.3 ± 0.1	6.8 ± 0.4	**13.4 ± 0.6**	**0.525 ± 0.026**

concentration in weight

Designation	^{238}U Bq kg^{-1} ± 1σ	^{235}U Bq kg^{-1} ± 1σ	^{234}U Bq kg^{-1} ± 1σ	U total Bq kg^{-1} ± 1σ	U total mg kg^{-1}± 1σ
ROGATICA (PC ITALIAN)	13 ± 1	1.2 ± 0.3	15 ± 1	**30 ± 2**	**1.06± 0.08**
Visoko (headquarters)	19± 2	3.3 ± 0.7	23 ± 2	**45 ± 3**	**1.6 ± 0.2**
Sarajevo (Port. Embassy)	144 ± 8	6 ± 1	156 ± 9	**306 ± 18**	**11.6 ± 0.7**

Table 30 – Uranium analysis in aerosol samples by alpha spectrometry. See Table 29 header.

Portugal – Sacavém

concentration in activity

Designation d/m/year	**^{238}U µBq m^{-3} ± 1σ**	**^{235}U µBq m^{-3}± 1σ**	**^{234}U µBq m^{-3}± 1σ**	**U total µBq m^{-3}± 1σ**	**U total ng m^{-3}± 1σ**
8 – 9/3/01	6.9 ± 0.5	0.4 ± 0.1	6.9 ± 0.5	**14.2 ± 1.1**	**0.56 ± 0.04**
9 – 10/3/01	6.2 ± 0.4	0.3± 0.1	6.2 ± 0.4	**12.7 ± 0.9**	**0.50 ± 0.04**
10 – 11/3/01	5.2 ± 0.4	0.3 ± 0.1	5.5 ± 0.4	**11.0 ± 0.9**	**0.42 ± 0.03**

concentration in weight

Designation d/m/year	**^{238}U Bq kg^{-1} ± 1σ**	**^{235}U Bq kg^{-1} ± 1σ**	**^{234}U Bq kg^{-1} ± 1σ**	**U total Bq kg^{-1} ± 1σ**	**U total mg kg^{-1}± 1σ**
8 – 9/3/01	92 ± 6	6 ± 2	92 ± 6	**190 ± 14**	**7.5 ± 0.5**
9 – 10/3/01	159 ± 11	7 ± 2	159 ± 11	**325 ± 24**	**12.9 ± 0.9**
10 – 11/3/01	74 ± 6	4 ± 1	78 ± 6	**156 ± 13**	**6.0 ± 0.5**

Table 31 – Uranium analysis of military personnel on mission in Kosovo and local people by alpha spectrometry. Samples collected by the scientific mission in January 2001.

Designation	**^{238}U mBq L^{-1} ± 1σ**	**^{235}U mBq L^{-1} ± 1σ**	**^{234}U mBq L^{-1} ± 1σ**	**U total mBq L^{-1} ± 1σ**	**U total ng L^{-1} ± 1σ**
# 1_b	0.8 ± 0.2	0.0 ± 0.0	1.4 ± 0.2	**2.2 ± 0.4**	**80 ± 10**
# 2_b	< 0.4	< 0.1	< 0.4	**< 0.9**	**< 33**
# 3_a	0.7 ± 0.3	0.2 ± 0.1	0.7 ± 0.2	**1.6 ± 0.5**	**59 ± 22**
# 4_a	1.4 ± 0.2	0.0 ± 0.0	0.3 ± 0.0	**1.7 ± 0.2**	**117 ± 18**
# 5_a	5.1 ± 0.4	0.1 ± 0.0	1.7 ± 0.2	**6.9 ± 0.6**	**411 ± 36***
# 6_a	0.8 ± 0.2	0.1 ± 0.0	0.2 ± 0.0	**1.1 ± 0.2**	**66 ± 18**
# 7_a	< 0.4	< 0.1	< 0.4	**< 0.9**	**< 33**
# 8_a	< 0.4	< 0.1	< 0.4	**< 0.9**	**< 33**
# 9_a	0.7 ± 0.2	0.0 ± 0.0	0.9 ± 0.0	**1.6 ± 0.4**	**56 ± 14**
# 10_a	0.7 ± 0.1	0.0 ± 0.0	0.2 ± 0.0	**0.9 ± 0.0**	**56 ± 12**
# 13_a	0.4 ± 0.1	0.0 ± 0.0	0.2 ± 0.0	**0.6 ± 0.0**	**32 ± 11**
# 14_a	2.8 ± 0.6	0.7 ± 0.4	1.6 ± 0.4	**5.1 ± 1.4**	**234 ± 64**
# 30_b	< 0.4	< 0.1	< 0.4	**< 0.9**	**< 33**
# 40_b	0.2 ± 0.1	0.2 ± 0.1	0.5 ± 0.2	**0.9 ± 0.2**	**36 ± 9**
# 42_b	< 0.4	< 0.1	< 0.4	**< 0.9**	**< 33**
Mean n = 8	**1.4**	**0.1**	**0.8**	**2.3**	**115**
Standard deviation	**1.5**	**0.2**	**0.6**	**2.1**	**120**
Min - Max	**0.2 – 5.1**	**0.0 – 0.7**	**0.2 – 1.7**	**0.6 – 6.9**	**32 - 411**

a – Local people serving the Portuguese military at Kosovo.
b – Portuguese militaries in mission at Kosovo.
*possible presence of depleted uranium

Table 32 – Uranium analysis in urine samples of military personnel on missions at BiH. Samples collected by the scientific mission in January 2001.

Designation	**^{238}U mBq L^{-1} ± 1σ**	**^{235}U mBq L^{-1} ± 1σ**	**^{234}U mBq L^{-1} ± 1σ**	**U total mBq L^{-1} ± 1σ**	**U total ng L^{-1} ± 1σ**
# 9	< 0.4	< 0.1	< 0.4	**< 0.9**	**<33**
#12	< 0.4	< 0.1	< 0.4	**< 0.9**	**<33**
# 13	0.2 ± 0.1	0.03 ± 0.00	0.4 ± 0.1	**0.6 ± 0.2**	**14 ± 6**
# 16	0.4 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	**0.7 ± 0.3**	**33 ± 14**
#19	0.3 ± 0.1	0.02 ± 0.00	0.5 ± 0.1	**0.8 ± 0.2**	**24 ± 2**
# 20	0.4 ± 0.1	0. 01 ± 0.00	0.4 ± 0.1	**0.8 ± 0.2**	**32 ± 8**
# 22	8.4 ± 0.8	0.5 ± 0.2	8.4 ± 0.8	**17.3 ± 1.8**	**682 ± 48***
# 24	0.9 ± 0.2	0.15 ± 0.10	0.9 ± 0.3	**2.0 ± 0.6**	**75 ± 21**
#29	< 0.4	< 0.1	< 0.4	**< 0.9**	**<33**
# 32	0.2 ± 0.1	0.04 ± 0.00	0.2 ± 0.1	**0.4 ± 0.2**	**17 ± 8**
# 33	< 0.4	< 0.1	< 0.4	**< 0.9**	**<33**
# 37	0.7 ± 0.2	0.1 ± 0.0	1.0 ± 0.2	**1.8 ± 0.4**	**58± 13**
Mean n = 8	**0.4**	**0.06**	**0.5**	**1.0**	**36**
Standard deviation	**0.3**	**0.05**	**0.3**	**0.6**	**22**
Min – Max	**0.2 – 8.4**	**0.01 – 0.5**	**0.2 – 8.4**	**0.4 – 17.3**	**14 - 682**

* not considered for the mean.

Table 33 – Uranium analysis by alpha spectrometry in civilian people who served in the Balkans. Samples collected in January 2001.

Designation	**^{238}U mBq L^{-1} ± 1σ**	**^{235}U mBq L^{-1} ± 1σ**	**^{234}U mBq L^{-1} ± 1σ**	**U total mBq L^{-1} ± 1σ**	**U total ng L^{-1} ± 1σ**
A	1.4 ± 0.2	0.07 ± 0.00	2.0 ± 0.3	**3.4 ± 0.5**	**110 ± 16**
B	0.25 ±0.09	0.04± 0.00	0.43 ± 0.10	**0.73 ± 0.29**	**21 ± 8**
C	2.5± 0.6	0.2 ± 0.2	3.4 ± 0.7	**6.2 ± 1.5**	**204 ± 50**
D	0.08 ± 0.04	0.05 ± 0.00	0.17± 0.10	**0.30± 0.16**	**7 ± 3**
E	< 0.4	< 0.1	< 0.4	**< 0.9**	**< 33**
F	0.16 ± 0.11	0.16 ± 0.16	0.21 ± 0.11	**0.52 ± 0.38**	**15 ± 6**
G	2.1 ± 0.5	0.1 ± 0.1	2.3 ± 0.6	**4.5 ± 0.2**	**170 ± 45**
H	0.21 ± 0.11	0.03 ± 0.00	0.16 ± 0.11	**0.40 ±0.22**	**17 ± 9**
I	<0.4	<0.1	<0.4	**<0.9**	**<33**
Mean n = 7	**1.0**	**0.09**	**1.2**	**2.3**	**78**
Standard deviation	**1.0**	**0.06**	**1.3**	**2.4**	**83**
Min - Max	**0.08 – 2.5**	**0.03 – 0.2**	**0.16 – 3.4**	**0.30 – 6.2**	**7 - 204**

Table 34 – Uranium analysis in urine samples of military personnel who served at Balkans. Individuals selected by military hospitals.

Individuals	**^{238}U mBq L^{-1} ± 1σ**	**^{235}U mBq L^{-1} ± 1σ**	**^{234}U mBq L^{-1} ± 1σ**	**U total mBq L^{-1} ± 1σ**	**U total ng L^{-1} ± 1σ**
1	4.3 ± 0.3	0.1 ± 0.1	4.5 ± 0.3	**8.9 ± 0.6**	**347 ± 23**
2	-	-	-	**-**	**-**
3	0.5 ± 0.1	0.1 ± 0.0	0.3 ± 0.1	**0.9 ± 0.2**	**34 ± 7**
4	1.7 ± 0.2	0.0 ± 0.0	3.6 ± 0.3	**5.3 ± 0.5**	**140 ± 13**
5	1.0 ± 0.2	0.1 ± 0.1	1.2 ± 0.2	**2.3 ± 0.4**	**82 ± 14**
6	-	-	-	**-**	**-**
7	1.5 ± 0.2	0.1 ± 0.0	0.9 ± 0.2	**2.5 ± 0.4**	**122± 19**
8	3.3 ± 0.7	0.1 ± 0.0	2.4 ± 0.6	**5.8 ± 1.3**	**267 ± 60**
9	2.1 ± 0.2	0.0 ± 0.0	1.4 ± 0.2	**3.5 ± 0.3**	**169 ± 19**
10	2.6 ± 0.7	0.7 ± 0.4	5.8 ± 1.0	**9.1 ± 2.1**	**222 ± 50**
11	0.4 ± 0.1	0.1 ± 0.0	0.9 ± 0.2	**1.4 ± 0.3**	**35 ± 7**
12	0.6 ± 0.1	0.0 ± 0.0	0.6 ± 0.1	**1.2 ± 0.2**	**47 ± 10**
13	3.8 ± 0.6	0.7 ± 0.3	1.7 ± 0.4	**6.2 ± 1.3**	**314 ± 66**
14	1.6 ± 0.3	0.4 ± 0.2	1.3 ± 0.3	**3.3 ± 0.6**	**134 ± 32**
15	0.08 ± 0.04	0.07 ± 0.07	0.20 ± 0.09	**0.35 ± 0.16**	**7 ± 4**
16*	1.2 ± 0.2	0.1 ± 0.0	1.9 ± 0.2	**3.2 ± 0.3**	**99 ± 12**
17*	< 0.4	< 0.1	< 0.4	**< 0.9**	**< 33**
Mean n = 14	**1.8**	**0.2**	**1.9**	**3.9**	**144**
Standard deviation	**1.3**	**0.2**	**1.6**	**2.8**	**108**
Min - Max	**0.08 – 4.3**	**0.0 – 0.7**	**0.2 – 4.5**	**0.35 – 9.1**	**7 - 347**

* reference people.

Table 35 – Uranium analysis in urine samples of civilians (reference group). Samples collected in January 2001.

Designation	**^{238}U mBq L^{-1} ± 1σ**	**^{235}U mBq L^{-1} ± 1σ**	**^{234}U mBq L^{-1} ± 1σ**	**U total mBq L^{-1} ± 1σ**	**U total ng L^{-1} ± 1σ**
A	1.9 ± 0.2	0.07 ± 0.00	2.1 ± 0.2	**4.07 ± 0.40**	**154 ± 15**
B	0.43 ±0.13	0.00 ± 0.00	0.45 ± 0.12	**0.88 ± 0.20**	**34 ± 9**
C	0.77± 0.2	0.23 ± 0.01	1.04 ± 0.18	**2.04 ± 0.36**	**65 ± 11**
D	1.6 ± 0.2	0.06 ± 0.00	0.2± 0.1	**1.86± 0.30**	**126 ± 24**
Mean n = 4	**1.2**	**0.12**	**0.95**	**2.2**	**95**
Standard deviation	**0.7**	**0.09**	**0.84**	**1.3**	**55**
Min - Max	**0.43 – 1.9**	**0.00 – 0.23**	**0.2 – 2.1**	**0.88 – 4.07**	**34 - 154**

Table 36 – Result of the cytogenetic analysis in lymphocytes. Individuals selected by the military hospitals.

Individuals	Age	Sex	Presence in the Balkan (days)	Number of observed cells	Chromosomic aberrations	
					Dicentrics	Frag+minutes#
1	23	M	30	500	0	1
2	31	M	180	500	2[a]	1
3	40	M	180	500	0	8
4	21	M	180	500	0	2
5	32	M	180	500	0	6
6	27	M	180	500	0	13
7	28	M	6	500	0	3
8	24	M	180	500	0	4
9	37	M	60	500	2	8
10	40	M	365	500	0	1
11	23	M	180	500	0	4
12	40	M	1550	500	0	5
13	27	F	180	500	0	1
14	33	M	365	500	0	1
15	30	M	180	401	1	2
16*	22	M	0	500	0	6
17*	22	M	0	500	0	3

- Chromosomic breaks. Fragments and minutes.
[a] - A tricentric was observed (equivalent to two dicentrics).
*- Control. Individuals who haven't been in service commission abroad.

Table 37 - Main parameters of the statistical analysis of the individuals analysed for uranium in urine.

Individuals analysed	**Number of Individuals**	**Mean net cpm L^{-1} (a)**	**Confidence interval ± 95%**	**Median net cpm L^{-1} (a)**	**Minimum net cpm L^{-1} (a)**	**Maximum net cpm L^{-1} (a)**
Military and Civilian Portuguese in Bosnia	871	2.87 ± 0.05	2.97 2.77	2.70	-0.10	10.5
Military and Civilian Portuguese in Kosovo	202	2.94 ± 0.11	3.16 2.72	2.74	-0.30	8.46
Military e Civilian Portuguese in Bosnia and in Kosovo (b)	34	2.75 ± 0.27	3.29 2.21	2.35	0.30	6.59
Military and Civilian in Portugal (grouped)	209	3.38 ± 0.10	3.57 3.18	3.20	1.00	8.24
Civilian in Portugal	60	3.34 ± 0.19	3.71 2.96	3.20	1.00	8.24
Military in Portugal	149	3.49 ± 0.12	3.63 3.16	3.20	1.07	8.02

(a) net cpm L^{-1} = net counts per minute per litre.
(b) Individuals who served in Bosnia and Kosovo; had not been included in the last groups.

Table 38 – Radioactivity in human tissues determined by gamma spectrometry (concentrations in fresh weight).

Identification	Designation	^{235}U Bq kg^{-1}±2σ	^{234}Th Bq kg^{-1}±2σ	^{234}Pa Bq kg^{-1}±2σ	^{226}Ra Bq kg^{-1}±2σ	^{210}Pb Bq kg^{-1}±2σ	^{137}Cs Bq kg^{-1}±2σ	^{40}K Bq kg^{-1}±2σ
Individual who was at Balkans	Brain	<2.0	<25.0	n.d.	<3.2	<399.8	<1.3	449.0 ± 20.1
	Liver	<2.5	<33.3	n.d.	<4.5	<136.3	<2.0	<47.8
	Kidney	<3.0	<39.5	n.d.	<4.9	<157.5	<2.2	<53.7
Reference 1	Brain	<14.6	<148.7	n.d.	<25.4	<249.2	<12.5	<396.2
	Liver	<21.7	<149.3	n.d.	<37.3	<373.7	<15.7	<716.2
	Kidney	<30.3	<242.8	n.d.	51.0 ± 9.5	<418.5	<20.2	<681.0
Reference 2	Brain	<13.9	<147.7	n.d.	56.6 ± 6.6	<252.8	<13.5	<406.0
	Liver	<13.5	<168.6	n.d.	32.1 ± 6.0	<419.9	<11.3	<339.4
	Kidney	<23.8	<302.2	n.d.	<26.6	<1001.0	<17.6	616.8 ± 358.0

n.d. = not detected

Table 39 – Uranium concentrations in human tissues by alpha spectrometry (concentrations in fresh weight).

Designation	^{238}U μBq g^{-1} ± 1σ	^{235}U μBq g^{-1} ± 1σ	^{234}U μBq g^{-1} ± 1σ	U total μBq g^{-1} ± 1σ	U total ng g^{-1} ± 1σ
Individual who was at Balkans					
kidney	5.6 ± 0.8	0.23 ± 0.08	11.5 ± 1.2	**17.3 ± 2.1**	**0.45 ± 0.05**
liver	11.8 ± 1.3	0.42 ± 0.15	13.8 ± 1.5	**26.0 ± 3.0**	**0.95 ± 0.11**
heart	4.5 ± 1.0	0.67 ± 0.34	8.2 ± 1.3	**13.4 ± 2.6**	**0.37 ± 0.07**
spleen	6.7 ± 1.2	0.0 ± 0.0	9.0 ± 1.3	**15.7 ± 2.5**	**0.54 ± 0.08**
muscle	42.0 ± 8.8	0.0 ± 0.0	68.9 ± 10.9	**110.9 ± 19.7**	**3.4 ± 0.6**
brain	34.9 ± 3.0	0.46 ± 0.17	33.5 ± 3.0	**68.9 ± 6.2**	**2.8 ± 0.2**
Reference 1					
kidney	5.7 ± 0.9	0.43 ± 0.43	6.4 ± 1.0	**12.5 ± 2.3**	**0.46 ± 0.09**
liver	15.8 ± 1.4	0.33 ± 0.33	16.8 ± 1.5	**32.9 ± 3.2**	**1.3 ± 0.1**
heart	8.8 ± 0.9	2.6 ± 0.6	7.9 ± 1.0	**19.3 ± 2.5**	**0.74 ± 0.09**
spleen	9.2 ± 0.9	2.4 ± 0.6	11.1 ± 1.1	**22.7 ± 2.6**	**0.77 ± 0.09**
muscle	9.0 ± 3.8	4.5 ± 3.0	14.2 ± 3.8	**27.7 ± 10.6**	**0.78 ± 0.30**
brain	7.8 ± 1.0	0.13 ± 0.13	9.4 ± 1.2	**17.3 ± 2.2**	**0.63 ± 0.08**
Reference 2					
kidney	38.5 ± 2.6	1.3 ± 0.6	46.6 ± 3.0	**86.4 ± 6.2**	**3.1 ± 0.2**
liver	10.0 ± 1.7	0.48 ± 0.48	15.1 ± 2.0	**25.6 ± 4.2**	**0.8 ± 0.1**
heart	25.1 ± 2.5	0.96 ± 0.72	23.6 ± 2.5	**49.7 ± 5.7**	**2.0 ± 0.2**
spleen	7.4 ± 1.2	0.38 ± 0.38	8.9 ± 1.3	**16.7 ± 2.9**	**0.6 ± 0.1**
muscle	35.2 ± 2.6	2.7 ± 0.8	39.1 ± 2.8	**77.0 ± 6.2**	**2.9 ± 0.2**
brain	86.7 ± 6.0	5.3 ± 1.8	90.2 ± 6.0	**182.2 ± 13.8**	**7.0 ± 0.5**