FEASIBILITY ANALYSIS OF THE DEVELOPMENT OF A SPECIAL SYSTEM FOR OBTAINING TOOTH SAMPLES FROM THE TECHA RIVER RESIDENTS

Milestone Report
for Project 1.1 "Development of an Improved Dose Reconstruction System for the General Population Affected by the Operation of the Mayak Production Association"

Milestone 2 for FY 1997 for the Urals Research Centre for Radiation Medicine
(Milestone 5 from the Project Master List)

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INTRODUCTION

A special task aimed at the development of a system for obtaining tooth samples from Techa River residents was suggested by the Scientific Review Groups (SRGs) during discussions at the Issue Resolution Meeting for "Dose Reconstruction Methodology for Population Studies Under JCCRER Program (Project 1.1)" in Washington, DC, February 10, 1997. The reason for this decision was the great importance of creating an objective basis for validation of individual external doses for members of the Techa River Cohort (TRC). It was agreed by Principal Investigators and the SRGs that the only experimental technique for individual external dose evaluation for this cohort is electron paramagnetic resonance (EPR) spectroscopy of teeth, and that the development of a special system is necessary to collect a sufficient number of teeth to provide a representative sample of subjects for the validation of calculated doses in the TRC.

Preliminary EPR studies of the Techa population have shown [1,2] that dose absorbed in tooth enamel consists of three main contributions: External exposure mainly from the Techa River bottom sediments; internal exposure mainly due to ^{90}Sr; and background radiation including all other sources of exposure except that arising from the Techa River. A pilot study demonstrated the applicability of EPR dosimetry using teeth to population-dose reconstruction in general and helped to formulate two tasks specific for the Techa River region: 1) The necessity to investigate the nature of relatively high background EPR signals that may be the result of local radioactive fallout from air releases from the Mayak facility and 2) The necessity to develop special methods to evaluate the contribution of ^{90}Sr to the dose to tooth enamel. It is impossible to extract the component contributed by external exposure to the total enamel dose without solving these two tasks. The pilot study also permitted determination of a strategy for tooth sampling as follows. It is necessary to collect enough teeth for three groups in the population with different kinds of exposure: 1) Exposure due to only background sources [people who did not live near the Techa River after the onset of radioactive contamination]; 2) Exposure due to ^{90}Sr ingestion with river water from the Techa plus background sources (the residents of the middle and lower Techa); and 3) External exposure from the Techa River bottom sediments plus internal exposure due to ^{90}Sr plus background radiation (the residents of the upper Techa). The special system for obtaining tooth samples for population-dose reconstruction proposed in this report is based on the above strategy.

DESCRIPTION OF THE COHORT UNDER INVESTIGATION: NUMBERS, TERRITORIAL DISTRIBUTION AND ARRANGEMENTS FOR TOOTH COLLECTION

The specific aim of Project 1.1 is to enhance reconstruction of external and internal radiation doses for the Techa River Cohort (TRC) numbering 33,500 individuals who lived in the Techa Riverside communities and were born before the onset of

radioactive contamination in 1949. The purpose of the enhanced dose reconstruction is to support companion epidemiological studies of radiogenic leukemia and solid cancers (NCI-RERF-URCRM Project and JCCRER Project 1.2). The TRC has already been reasonably well defined by the companion epidemiological studies. According to information currently available in the URCRM database "MAN," 13,200 members of the TRC have died and 1,500 individuals have migrated from the Urals region. For the remainder of the 18,800 subjects, actual information on the place of residence is available for 16,000. All these numbers are presented in round numbers, because exact numbers are changing as a result of current work on the improvement of epidemiological data. Table 1 presents data for rural raions* and towns of the Urals region, where TRC subjects are currently concentrated.

Table 1. List of administrative rural raions and towns of the Urals region in which the population includes more than 20 living subjects of the TRC.

Name of raion or town	Number of TRC subjects currently residing
Chelyabinsk	2,782
Krasnoarmejsky Raion, Chelyabinsk Oblast[a]	2,601
Kunashaksky Raion, Chelyabinsk Oblast	2,193
Katajsky Raion, Kurgan Oblast	1,818
Dalmatovsky Raion, Kurgan Oblast	1,517
Sosnovsky Raion, Chelyabinsk Oblast	634
Ekaterinburg	519
Kamensk-Uralskii	408
Argayashsky Raion, Chelyabinsk Oblast	322
Ozyorsk	246
Kaslinsky Raion, Chelyabinsk Oblast	208
Shadrinsky Raion, Kurgan Oblast	138
Kurgan	118
Shadrinsk	116
Verhnyaya Pyshma	103
Novogorny	79
Kyshtym	76
Berezovsky Raion, Sverdlovsk Oblast	48
Kamensky Raion, Sverdlovsk Oblast	44
Beloyarsky Raion, Sverdlovsk Oblast	35
Asbest	33
Sysertsky Raion, Sverdlovsk Oblast	31
Bogdanovichsky Raion, Sverdlovsk Oblast	21

[a]An oblast is an administrative-political unit roughly equivalent to a state in the United States.

* A raion is an administrative-political unit roughly equivalent to a county in the United States.

It is obvious that the TRC members initially living on the river are now scattered throughout the Urals region due to intensive migration, but 8,129 subjects (more than 50% of living TRC members with known place of residence) are concentrated in four rural raions: Kunashaksky, Krasnoarmejsky, Katajsky and Dalmatovsky. It must be noted that the rural population receives dental care predominantly in Central Raion Hospitals (CRH) located in raion centers. It seems reasonable to arrange long-term agreements (aimed to collection of all teeth extracted by dentists for purposes of dental health) with CRHs of these four raions where TRC members make up 20–25% of the total population cohorts of the same ages. Unfortunately, it seems unreliable to arrange tooth collection in Chelyabinsk, because there are numerous dental clinics in this city and TRC members make up less than 1% of the total population cohorts of the same ages.

Special attention must be paid to the subcohort of upper Techa River residents, because high levels of external exposure are expected for these people [3]. Only 17% of this subcohort (numbering in total 2,245 living subjects with known place of residence) are living now within the above selected four rural raions (Table 2).

Table 2. List of administrative rural raions and towns of Chelyabinsk Oblast in which the former residents of the upper Techa live now.

Name of raion or town	Number of TRC subjects currently residing
Chelyabinsk	434
Krasnoarmejsky Raion	133
Kunashaksky Raion	245
Sosnovsky Raion	462
Argayashsky Raion	263
Ozyorsk	214
Kaslinsky Raion	137
Novogorny	63
Kyshtym	42

Analysis of the territorial distribution of the 38% of the upper Techa subcohort subjects who live within Sosnovsky, Argayashsky and Kaslinsky Raions shows that these people are concentrated predominantly in three state farms (Table 3).

Table 3. State farms with high concentrations of living TRC members within Sosnovsky, Argayashsky and Kaslinsky Raions.

Name of state farm, raion	Number of TRC members	% of total number of TRC members living in raion
Muslyumovsky, Sosnovsky Raion	346	55
ONIS, Kaslinsky Raion	113	54
Hudajberdinsky, Argayashsky Raion	77	24

It seems reasonable to arrange long-term agreements with the CRHs of the three above raions, but these agreements must be aimed at collection of selected teeth for the members of these three state farms where TRC members make up about 20–25% of the total population cohorts of the same ages.

The arrangements proposed will permit observation of about 55% of living TRC members with known place of residence and receipt of tooth samples from other residents of the Urals region exposed to only background sources. Such arrangements may provide a representative sample of subjects with individual EPR doses after several years of work.

REGISTRATION AND STORAGE: THE BANK OF SAMPLES AND THE DATA BASE

The first task of sample registration is how to arrange the matching of tooth donors with the roster of the TRC. It is possible to use special tools developed in the framework of Data Management System MAN [4] and available at the URCRM for this purpose. The experience of the pilot study shows that proper matching can be performed by URCRM staff members, and that such matching permits extraction of supplemental information for TRC members from database MAN and the URCRM archive (exposure history, whole-body count, x-ray examinations etc.). It is suggested to arrange transportation of collected teeth once per quarter, together with personal information from the tooth donors, from the CRHs to the URCRM for matching, registration and storage. Each tooth sample must be packed in a plastic bag together with a completed questionnaire. Each questionnaire must include the following information about the tooth donor: Surname, name, patronymic name, date of birth, place of birth, current place of residence, other places of residence since 1949, date of tooth extraction, and tooth position. URCRM experience shows that such information is enough for exact matching with the TRC roster. There is no practice of x-ray examination of teeth in the CRHs now. The information on other x-ray examinations for TRC subjects can be abstracted from their out-patient cards kept in the URCRM archive. After matching, all data on extracted teeth must be registered in a special computer file of data base MAN, and all tooth samples, in special containers marked with identification codes, must be kept in a refrigerator.

HUMAN-SUBJECT CONSIDERATIONS

As noted above, the collection of teeth will be made only if teeth are being removed for purposes of dental health. Such conditions will be explicitly included in the agreements with CRH administrations and confirmed by dentists' signatures. Also, the work on teeth collection will be performed under the guidance of URCRM's Institutional Review Board (IRB) and IRBs appropriate for any institutions in Russia and the US that may receive samples. Confidentiality of all information will be assured by restricting access to identifying personal information to one institution in Russia (URCRM). Any

information of an individual nature derived during the course of this project will be made available to the affected individual.

PRELIMINARY EVALUATION OF CAPABILITY AND COST

For testing the proposed system, a preliminary agreement (aimed at collection of all teeth extracted for purposes of dental health) was arranged with the Kunashaksky CRH. During three months (March, April, and May 1997), 60 tooth samples, including 15 samples (25% of the total number) belonging to TRC members, were collected and registered. Three collected samples (5% of the total number) belonging to persons exposed as a result of the Kyshtym Accident in 1957 could not be used as background (they were identified as members of the East Urals Radioactive Trace (EURT) Cohort). So it is feasible to receive about 150–170 background tooth samples and about 50–70 exposed samples for TRC members from each of four CRHs per year. This could give in total about 200–300 exposed samples and about 600–700 background samples per year. The operation of such a system over a five-year period could give about 1,000–1,500 exposed tooth samples and about 3,000–3,500 background samples. (Not all background samples would need to be analyzed.) Such a distribution of subjects would permit investigation of the nature of the EPR background signal and could be evaluated as representative for dose reconstruction in the TRC. The estimated cost of such a system is about $3,000–$4,000 per year (payments to dentists and registrars; transportation, and supplies), based on expenses incurred with the preliminary agreement.

ARRANGEMENTS FOR MEASUREMENTS OF TOOTH SAMPLES

The results presented in the above sections illustrate that it is feasible to collect about 1,000 tooth samples per year for analysis by electron paramagnetic resonance for the purposes of dose reconstruction in the Techa River Cohort. After background effects are evaluated, the majority of the analyses will be of the TRC samples. However, the entire inventory of teeth must be dealt with at URCRM because identification as TRC members cannot be made at the CRHs. Thus, the total number of teeth analyzed with EPR spectroscopy will be about 200–250 per year. It seems reasonable and advisable to establish a special EPR dose-reconstruction center in the Urals to perform routine measurements. Additional arguments for the establishment of such a center include the necessity of dose validation for the Mayak Worker Cohort (JCCRER Project 2.4) and Ozyorsk Children Cohort (NCI-RERF-FIB-1 Project). The development of these projects could result in additional significant numbers of Ural tooth samples for EPR analysis. It seems unreliable and expensive to arrange regular transportation of such large numbers of samples for EPR measurements to laboratories located at long distances from the Urals. A good candidate for the location of such a local center is the EPR Spectroscopy Center of the Metal Physics Institute located in Ekaterinburg. The highly qualified research team working in this laboratory has the experience of collaborative work on EPR dose reconstruction with URCRM and Mayak, as well as with US and European scientists [1,2,5]. They also have all necessary equipment for sample preparation. Unfortunately,

the head of this center Dr. A. Romanyukha (who is also a Task Leader of JCCRER Project 1.1) does not have a suitable working spectrometer. Preliminary negotiations with Bruker (a German company that is the main producer of EPR spectrometers with shipments throughout the world) were made. According to the quotation received from Bruker, and given in the Appendix, the price of an EPR spectrometer is $248,270. Custom duties will be an additional $3,500, so the total expenses will be about $252,000, which is in accordance with the budget request form of Project 1.1 for FY1998.

It must be noted that the time for spectrometer delivery and installation will be about six months. Therefore, it is necessary to initiate purchase of an EPR spectrometer for fulfillment of Project 1.1 as soon as possible, because otherwise the time to make EPR measurements of 180 tooth samples (planned in Project 1.1) will be too tight. If a new EPR spectrometer is purchased, the administration of the Metal Physics Institute (MPI) has agreed to provide a separate room for it and one additional position for staff. Exploitation of additional equipment, such as an EPR spectrometer, will require additional overhead expenses. Therefore, it will be reasonable to initiate a separate contract with the Institute of Metal Physics. It is estimated that the cost will be $25,000 per year.

It is feasible and desirable to arrange independent EPR measurements for some portion of the teeth collected in the Urals region. EPR laboratories at the Medical Radiological Research Center (MRRC), Obninsk (Dr. V. Skvortsov), and at the Moscow Biophysics Institute (MBI) (Dr. E. Kleschenko) have confirmed their readiness to participate in such work. Dr. E. Haskell (University of Utah, Salt Lake City, USA), who is a collaborator of Project 1.1 as Quality Assurance Leader, has suggested arranging intercomparisons between MPI, MRRC, MBI, and University of Utah that would be the first step for such independent measurements. These proposals confirm the perspective of EPR studies in the Urals and should be considered as the development of the work started in the framework of JCCRER Project 1.1.

CONCLUSIONS

This analysis of the territorial distribution of living subjects included in the Techa River Cohort shows that it is feasible to arrange a special system for obtaining tooth samples, if agreements can be established between the URCRM and the Central Raion Hospitals of seven selected rural raions of the Chelyabinsk and Kurgan Oblasts. Such a system will keep under observation about 55% of the living members of the TRC and provide about 200–300 exposed samples and about 600–700 background samples per year. The cost of such a system is estimated to be about $3,000–$4,000 per year.

It is feasible to establish at the URCRM a bank of tooth samples for the exposed Urals population. Establishment of such a bank will permit receipt in the next few years of a sample of subjects for whom individual EPR doses could be measured, and this sample will be representative for the Techa River Cohort as a whole. All human-subject considerations will be taken into account in establishing this bank.

It is feasible to establish a special EPR-dose-reconstruction center at the Metal Physics Institute, Ekaterinburg, to perform routine measurements of the Urals tooth samples. Highly qualified researchers and all necessary equipment for the preparation of the tooth samples are available there. If this laboratory can be provided with a new EPR machine (Bruker EPR system, about $252,000), they could perform about 200–250 measurements per year and create an objective basis for individual external dose validation for the Techa River Cohort in the next few years.

Establishing long-term EPR studies in the Urals (including teeth collection and EPR measurements) is very promising. Other local exposed cohorts (Mayak workers, EURT residents, Ozyorsk children) as well as some other EPR laboratories (MPI, MRRC, MBI) could be involved in these investigations in the future.

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APPENDIX

BRUKER ANALYTIK GMBH
Kernresonanz · Elektronenresonanz · FT-IR · QC · MS · ICR · Magnetsysteme · Elektronische Geräte · Computerbau

Quotation No. 97-g3

Institute of Physics of Metals UrO RAN
Prof. ROMANYUKHA A.A.

Pos.	Description	Price DM
1	E 500 EPR Spectrometer System ELEXSYS	405.600,-
	E-500-10/2.7 system with 10" magnet, 2.7KW power supply	
	ER 073 10" magnet	
	ER 073-1003 ring shim polecaps	
	ER 081 2.7KW magnet power supply	
	E-513-S E500 single door console incl.power supply and wiring	
	E-027 single master base station with E527H high frequency unit incl. modulation amplifier	
	E-527-H high frequency signal channel 6-100KHz in 1Hz steps 0.1 degr. phase resolution	
	ER-032 microprocessor hall field controller -50G to 23kG	
	ER-48MBC microwave bridge controller	
	ER-041X high power X-band microwave bridge 400mW	
	ER-041FC X-band digital frequency counter 1KHz to 10GHz	
	ER-4102ST high sensitivity rectangular standard cavity	
	E-532-M data system main frame unit with VME bus slots	
	E-432-CPU 68040 CPU(32 bit data bus,32 bit address bus) 8Mbyte on board dual ported memory, VME bus, Ethernet	
	E-532-GIS general purpose spectrometer interface RS232C, centronics, IEC625,SLD-bus,3 programmable output pulses, 2 interrupt lines	
	E-532-ADF high speed digitizer,2 channels, 2MHz sampling rate hardware accumulator with 8Kx32bit on board memory	
	E-532-RSC digital rapid scan controller up to 2000G sweep width sweep time:500usec-3.3sec,modulation 61Hz-100KHz	
	E-532-TVI transputer interface board	
	E-5000-SGI INDY R5000(Silicon graphics) 12MB memory,2GB disk, CD-ROM drive, 2 Ethernet interfaces, 17" colour monitor	
	E-532-LJ Laser jet 5L or equivalent	
	E-5000-OS operating system installation package	
	E-5000-Xepr EPR software package	
	E-5000-Aepr Acquisition software	
	E-5000-FDepr functional devices transputer software	
2	B-H 15 B bipolar Hall controller for magnetic field measuring and stabilizing , range resolution for center field	22.600,-
	-12 KG to +12 KG with 50 mG resolution	
	-23 KG to +23 KG with 100 mG resolution	
	Price ex-works	428.200,-
	Discount for 100% prepayment - 5%	21.410,-
	Total	406.790,-
3	Packing, marking, assurance, transport to Ekaterinburg	12.860,-
	Grand total CIP Ekaterinburg DM	**419.750,-**
	Grand total CIP Ekaterinburg US $ of 12 May 1997*	**248.270,-**

* - Prices are fixed in DM. Payment is to be effected in US $ at the rate by the date of payment.

Д-р Уве Айххофф 12 May 1997

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