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PROGRESS REPORT AND PROPOSAL

FOR RENEWAL OF LOAN OF A 90° BENDING MAGNET

FOR USE IN THE STUDY OF

TRACE ELEMENTS IN THE ENVIRONMENT AND DISEASE

[U.S. AEC Contract #AT-(40-1)-4697]

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A. PROGRESS REPORT

The following studies were undertaken during the 1974 calendar year after the completion of installation of the Van de Graaff (VDG) accelerator and the associated analysis equipment.

1. Completion and testing of the computer program (MAX-1) for multi-element analysis of X-ray emission spectra. This program written in FORTRAN IV stores characteristic X-ray line shapes and energies for 33 elements (the list is periodically updated according to requirements) on a disc along with accurately measured relative characteristic X-ray yield data for all these (and other) elements. The program calculates the energies of all peaks observed in a certain X-ray spectrum and accepts the presence of an element if at least two lines pertaining to that element are identified in the spectrum. Characteristic X-ray spectra of positively identified elements are stripped from the total spectrum in a predetermined order (with regard to atomic number) with built in criteria to monitor over and under stripping. After all the characteristic X-ray "lines" for the predominant element have been stripped from a spectrum, the residual spectrum is reanalyzed in exactly the same manner as a new spectrum. This process is continued until the spectrum is stripped down to the level of the background. Elements that are not positively identified in the spectrum are assigned upper limits for their fractional abundance determined from the statistical uncertainty in the number of counts at the location of the X-ray lines from that element.

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2. Analysis of water samples from a treatment plant and some test samples from EPA.

Procedures for quantitative analysis of water samples by proton-induced X-ray emission techniques were developed. Considerable effort was expended in determining the sources of contamination of these samples when it is desired to know the concentrations of several elements down to 0.1 ppb. Studies were also made to determine any possible change in the trace element concentration of these water samples as a function of storage time and conditions such as acidity, temperature, etc. A report that was sent to EPA discussing several of these procedures is attached.

3. Linear scans of long strands of human hair for variations in their elemental composition as a function of distance from the root of the hair using a well collimated proton beam from the VDG accelerator. The object of this study was to determine if the history of exposure of individuals to varying concentrations of toxic metals is recorded in their hair. A brief discussion of procedures and results published in the proceedings of a conference on the uses of low energy accelerators (North Texas State University Physics Dept., 1974) is attached.

4. Elemental analysis of bulk hair specimens collected from residents in the vicinity of a copper smelter. The object here was to determine the level of toxic elements such as As, Pb, Hg, Cd, Sb, etc., in the hair of the donors residing in the vicinity of the copper smelter and to compare the levels observed in these samples with those in specimens collected from remote relatively unpolluted areas. Preliminary studies to optimize the analysis technique and to decide on an internal standard to be introduced into the hair specimens were made. Sample prep-

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aration procedures to ensure minimum contamination and loss of trace elements, and a uniform homogeneous thin deposit of a solubilized and doped (with an internal standard) sample on a thin (1/7 mil) mylar film were developed and tested. Several samples have been analyzed. An example is shown in Fig. 1.

5. Analysis of aircraft exhaust aerosol samples collected from an airfield.

The object of these studies was to determine if heavy toxic elements such as Pb tend to concentrate in small size aerosols that land in the deep pulmonary regions and therefore present a potential health hazard. A letter on this subject submitted to Applied Physics Letters for publication is attached.

B. REQUEST FOR RENEWAL OF LOAN OF 90° BENDING MAGNET

As pointed out in our first proposal submitted to the AEC on February 25, 1974, the magnet will be used in our trace element laboratory for:

i) VDG accelerator beam analysis so that we have a proton beam free from molecular and other ion components and of well defined energy for our proton-induced X-ray emission studies, and

ii) for reducing the signal to background ratio in our X-ray Si(Li) detector by permitting the sample chamber and detector assembly to be completely isolated from the VDG accelerator.

Trace element studies that are planned for the 1975 calendar year include the following:

i) Correlation between the level of trace elements in the serum and cancerous tissue obtained from cancer patients. Alterations in

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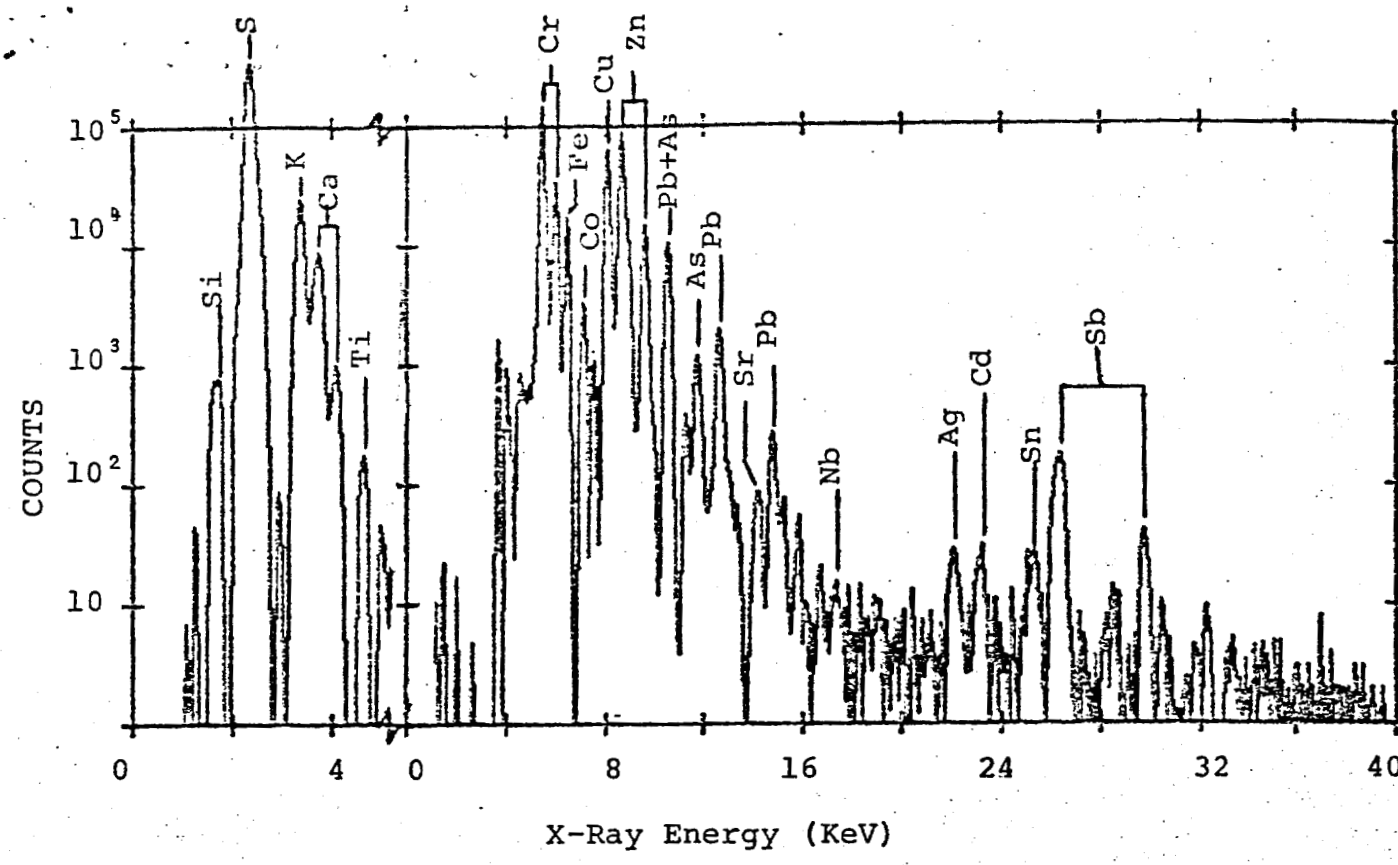

Fig. 1: Proton-Induced X-ray spectrum of a human hair sample. Table below shows the concentrations of the various elements observed. Cr is added to the sample as an internal standard for quantitation. Sb lines originate in the mylar substrate for the sample. For the elements where the second column shows a zero, the values in the first column indicate an upper limit.

Digested Human Hair Sample

ELEMENT	CONC(PPM)			ELEMENT	CONC(PPM)		
				SE	8.25	+-	0.00
SI	3414.60	+-	0.00	BR	1.56	+-	0.00
P	1333.86	+-	0.00	RB	0.30	+-	0.00
S	45188.39	+-	148.01	SR	1.16	+-	0.11
CL	1119.47	+-	0.00	Y	1.04	+-	0.00
K	2134.90	+-	16.27	ZR	0.39	+-	0.00
CA	0.04	+-	0.00	NB	0.47	+-	0.11
TI	36.22	+-	0.00	MO	0.33	+-	0.00
V	13.74	+-	0.00	AG	2.42	+-	0.28
CR	670.00	+-	6.26	CD	2.73	+-	0.33
MN	32.22	+-	0.00	SN	5.27	+-	0.63
FE	47.36	+-	2.51	SB	0.00	+-	0.00
CO	4.53	+-	0.00	I	3.03	+-	0.00
NI	2.31	+-	0.00	BA	5.76	+-	0.00
CU	162.15	+-	0.68	HG	1.74	+-	0.00
ZN	228.11	+-	0.74	PB	14.87	+-	0.21
AS	35.67	+-	0.91	BI	3.75	+-	0.00

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the level of these trace elements in the serum before, during and after therapy will also be investigated.

ii) Contamination of studies on elemental composition of aerosols as a function of size with filters that are designed at VARC to improve the aerosol collection efficiency at each stage of the cascade impactor. Studies are also planned to classify the aerosols with the greater size resolution achievable with a spiral centrifuge size spectrometer so that models for the concentrations of various trace metals in size classified aerosols can be developed to explain the observed results. Plans are also being developed to perform animal experiments with laboratory generated aerosols that are specially enriched in trace metals such as Pb, Cd, As, Ni, V, etc. to study the regions of animal anatomy where these elements accumulate and their effect on the general health and specific functions of various organs in these experimental animals.

iii) Studies in the alteration of trace element composition of blood and organs in mice as a function of different doses of radiations of different LET. This study will be undertaken simultaneously with other radiobiology work that is currently in progress at VARC and the NASA Space Radiation Effects Laboratory.

iv) Correlation between the level of trace metals in the blood and hair (at the root and beyond) at various times over an extended period of time. The concentration of trace metals in hair near the root will be observed for alterations as that segment of hair grows out to some distance from the root. The object is to determine the extent to which hair can be used as a record of levels of various trace metals in the blood at various times in a donor's health history.

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