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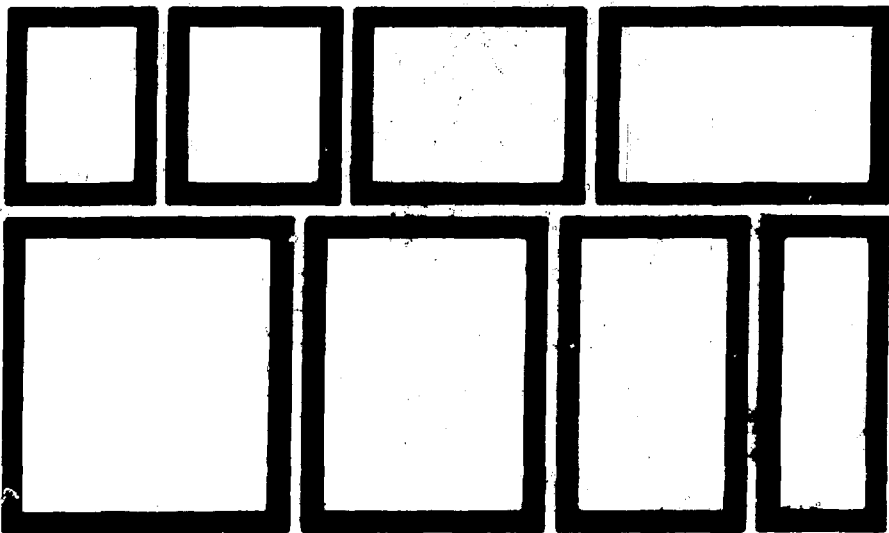
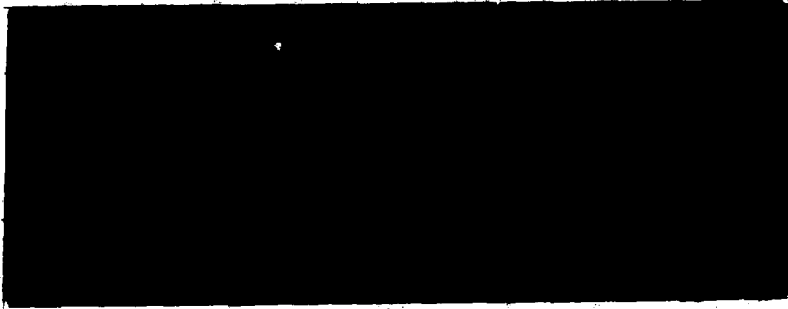
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MALAYSIA

**INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS
OF SOIL SAMPLE**

by

ABD KHALIK HJ WOOD

Paper Presented at the
IAEA Seminar On Effective Utilization
and Management of Research Reactor
7-11 November, 1983
Kuala Lumpur
MALAYSIA

INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS OF SOIL SAMPLE

by

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Abstract

This paper describes the analysis of soil samples collected from 5 different location around Sungai Lui, Kajang, Selangor, Malaysia. These samples were taken at 22-24 cm from the top of the ground and were analysed using the techniques of Instrumental Neutron Activation Analysis (INAA). The analysis on soil samples taken above 22-24 cm level were done in order to determine if there is any variation in elemental contents at different sampling levels.

The results indicate a wide variation in the contents of the samples. About 30 elements have been analysed. The major ones are Na, I, Cl, Mg, Al, K, Ti, Ca and Fe. Trace elements analysed were Ba, Sc, V Cr, Mn, Ga, As, Zn, Br, Rb, Co, Hf, Zr, Th, U, Sb, Cs, Ce, Sm, Eu, Tb, Dy, Yb, Lu and La.

1. INTRODUCTION

The elements in uncultivated soils come originally from rocks that weathered to form the soil. Basically the elements may be divided into two main categories, that is major elements and trace elements. The major elements in geological samples are Si, O, Al, Fe, Mg, Ca, Na Ie, Ti and P (>1.0%). Any elements with the concentration of less than 1.0% is considered as trace elements (1).

Instrumental Neutron Activation Analysis is the analytical technique for multielemental analysis. Samples and standards were irradiated with thermal neutron for a certain period of time, the activity were counted on the high resolution semi conductor detector for identification and quantification of the elemental contents. The soil contains mostly Silica (SiO_2 >70%) which is not easily activated with thermal neutron ($\sigma = 0.107$ barns) offer the most convenient matrix for the INAA. In general, the contents of elements in soil are relatively higher than these in biological sample, thus allows many elements can be determined easily.

This study is part of preliminary work on the main project of utilizing this technique for total elemental analysis of soil and soil solution in various types of Malaysian soil. This technique is chosen because of its sensitivity, non destructive and capability to do multielemental analysis. The application of INAA for soil and soil solution analysis were used by many workers (2,3,4).

2. PREPARATION OF SAMPLES AND STANDARDS

2.1 Collection and preparation of Samples

The samples were collected at five different places as shown in the map marked as F,G,J,K and I, along Sungai Lui's area in Kajang. Selangor. The samples were collected at the depth of 22-24 cm from the surface of the soil. At stations F, J and K, the samples at the depth of 0-20cm were also collected in order to check if there are any variation of the of the elemental contents due to the sampling level. The samples were collected by the method described by campbell et. al (5) and Mc Callan et.al (6). All of the samples were stored in polythere bags. They were dried in an over for 24 hours at 105°C and were then ground using the mortar and pestles. About 1 or 2 g were taken and redried again to a constant weight. About 0.1 to 0.15 g were taken into a clean polythene vial and heat sealed before sending to reactor for neutron irradiation.

2.2. Preparation of Standard

The standard used for the quantification most of the elements are secondary standards, that is IAEA soil-5, IAEA lake sediment SL-1 and NBS coal ash (1632a). The elemental contents in these reference material were taken from their certificates of reference material, except for the NBS coal ash (1632a), where the elemental contents were from reference 7. The elemental contents in these reference material were further analysed in this laboratory using primary standards prepared by dropping the elemental solution on to specpure SiO_2 and was dried in desiccator. The standard reference materials were dried in oven at 105°C for about 24 hours. About 0.1 to 0.15g were taken into a clean polythene vial and heat sealed. The neutron irradiation and the analysis will be discussed in section 3.

Some of the elements in those reference material were analysed by using one or two of the materials as the standards. Table 1, shows the elemental contents in these reference materials obtained in this work and those reported by other workers.

3. IRRADIATION AND COUNTING

Table 2, shows the list of radionuclides which can be detected in the soil sample. For short lived isotopes, the irradiation was performed for 2 to 5 minutes at the flux of about $1 \times 10^{12} \text{ n cm}^{-2} \text{ s}^{-1}$, using the rabbit system of the PUSPATI's Triga Mk II reactor. After 20 minutes of decay interval the elements analysed were Mn, Ti, Mg, Ca, V, Al, Na, Dy, I, Br (^{80}Br) and Cl. After 12-24 hours decay, As, Sb, Sm, K, Na and Br were detected and analysed.

For the medium and longer-lived radionuclides longer irradiation are required. The sample and standard were irradiated in the rotating rack of the PUSPATI's Triga Mark II reactor for about 6 hours at the flux density of about $1 \times 10^{12} \text{ n cm}^{-2} \text{ s}^{-1}$. After allowing 3-4 days decay, the following isotopes were detected: Br (^{82}Br), Sm, U, Yb, Ba, Nd, Lu, La, Ce, Sc and Rb. After about 1 month decay interval the radionuclides detected were Eu, Tb, Th, Cr, Zn, Sc, Rb, Fe, Co, Cs, Ta and Ce.

The sample and standard were counted in the polythene vial using the hyperpure germanium semiconductor detector for 5 minutes for short lived isotopes, at a reasonable dead time ($<20\%$). For longer half-lived isotopes the counting time required are from $\frac{1}{2}$ to $1\frac{1}{2}$ hours. The detail description of the counting and the data acquisition system has been described in the previous paper. The NAA software package from Nuclear Data were used for the elemental quantification.

4. INTERFERENCE

Table 2, shows the list of possible interference which may cause some error in the determination. There are two types of interference to be considered. They are the interference from the secondary reaction and the interference from gamma rays of another radionuclide. The latter could be avoided using another gamma rays of the radionuclide which is free from any interference. For example in the determination of ^{28}Mg , the less intense photopeak at 1014 keV was chosen instead of the most intense photopeak of 844 keV photopeak, since this peak interfered by the 846 keV of ^{56}Mn .

The interference from the secondary reaction were experimentally determined by irradiating the pure elements of Si, Al, Mg and Fe for 5 minutes in the rabbit system. The standard of Al, Mg, Mn and Na was prepared by dropping solution containing 500 μg of the Al, Mg, Mn and Na on the filter paper. The filter paper was dried in a desiccator. From the results shown in Table 3, it is clear that the interference in the determination of Mn, Na and Al are not significant, except for the determination of Mg. In the case of magnesium, if the sample containing 10% Al as much as 2.76% Mg would be produced. The correction for the determination of this element was done using the interference programme of the NAA packages.

5. RESULTS AND DISCUSSION

Apart from interference as discussed in section 4, some other factors may cause some errors in this analysis. They are contamination, homogeneity, effects of matrices and irregularity in the neutron flux density in the rabbit or in rotating rack systems. The problem in sample homogeneity is arisen because of only a small portion of the sample were taken for the analysis (0.1 - 0.15g). However this problem can be minimised by randomly taken the sample and carried out more than one analysis. The final results represent the average of each determination. The effect of matrix was not severe, since the IAEA soil-5 and lake sediment SL-1 were used as the standard or reference which are physically and chemically common to the samples. The uncertainty due to flux variations can be reduced by using several standards for the quantification of the elemental contents.

Table 4 shows the list of elemental contents in samples collected from the station F,G,J,I and K. It shows that this method is good for the analysis of most of the elements. However, the relative standard deviation more than 15% are noticed in the determination of Hf, Ce, Cl, I, Zn, K and Cr. The error may be minimized by optimizing the counting or the irradiation time.

Table 5, 6 and 7 show the list of elemental contents at various depths for station F, J and K, respectively. Some of the elements seems to be increased in their concentration as the depths increased (Figure 2,3 and 4). This may be due to the organic matter near the surface of the soil which has dilute the elemental contents.

References

1. Laul, J.C. Atomic Energy review 17, 3 (1979)
2. Nadkarni, R.A. Radiochem. Radioanal. Letters 26(2)
3. Bate, L.C.J. Radioanal. Chem., 15, 193 (1973)
4. Buenafama, H.D.J. Radioanal Chem. 18, 111 (1973)
5. Campble, B.L., R.J. Loughran and G.L. Elliot, Australian Geographical Studies (in press).
6. McCallan, M.E., B.M. O'Leary and C.W. Rose, Aust. J. Soil. Res. 18, 119 (1980)
7. Germani, M.S. I. Golemen, A.C. Sigleo, G.S. Kowalczyk, I. Olmez, A.M. Small, D.L. Anderson, M.P. Failey, M.C. Gulovali, C.E. Choquette, E.A. Lepal, G.E. Gordon and W.H. Zoller., Anal. Chem., 52(2), 1980.
8. Fardy, J.F., AAEC, unpublished data (Private Communication)

Table 1: List of Elemental contents in IBER's Soil-5, Lake Sediments(LK-1) and MBS Coal ash (1632a)

Elements	<u>Soil-5</u> <u>this work</u>	<u>Lake</u>	<u>Lake sediments SL-1</u> <u>this work</u>	<u>MBS</u>	<u>Coal ash</u> <u>this work</u>	<u>from ref. 7</u>
Ti	0.38±0.04	(0.47)	0.53±0.04 ⁱⁱ	0.517±0.037	0.11±0.009 ⁱⁱⁱ	0.161±0.001
Al	8.25±0.50	8.18±0.29	9.4±0.7	(8.9)	2.97±0.3	2.94±0.13
Fe	4.82±0.06	4.45±0.11	6.14±0.32	6.74±0.17	1.14±0.11	1.16±0.03
Mg	1.4±0.4	(1.5)	2.64±0.8 ⁱⁱ	(2.9)	0.20±0.04	0.13±0.03
Ca	1.93±0.2	(2.2)	1.34±0.02	(0.25)	0.25±0.03	0.23±0.02
Na	1.80±0.1	1.82±0.11	0.175±0.012	0.172±0.012	0.088±0.007	0.085±0.004
K	1.75±0.31	1.86±0.15	1.1±0.1	(1.1)	0.11±0.03 ⁱⁱⁱ	0.42±0.02
Mn	340±20	251±37	3510±290	3460±160	30.5±4.0	32±1
Sc	13.9±0.1	14.9±0.16	18.50±1.3	17.30±1.1	7.00±0.5	6.80±0.6
V	140.0±5.0	(151.0)	185.00±12	170.00±12	48.50±4.0	44.00±3.0
Cr	28.85±1.4	28.9±1.3	101.1±1.0	104.0±9.1	31.00±3.0	34.00±2.0
Cu	10.0±0.05	11.70±0.70	19.0±1.8	19.80±1.5	6.20±0.3	6.50±0.2
Zn	478.30±50	309.00±4.2	278.00±15.0 ⁱⁱ	223.00±10.1	-	31.00±6.0
Sb	15.09±3.0	14.30±2.8	1.75±0.24	1.51±0.12	0.81±0.10	0.60±0.09
Kb	173.00±3.5	138.00±7.4	112.00±5.0 ⁱⁱ	113.00±11.0	25.00±2.0 ⁱⁱⁱ	29.00±1.0
Cs	61.10±5.0	56.70±5.3	8.50±1.5 ⁱⁱ	7.01±0.98	-	2.00±0.30
Ra	405.00±20.0	562.00±53.0	640.00±70.0	639.00±53.0	110.00±7.0	122.00±11.0
Sr	273.00±11.0	(330.00)	78.60±18 ⁱⁱ	(80)	79.90±15 ⁱⁱⁱ	84.00±9.00
Lu	30.70±1.1	18.10±1.5	42.0±4.5	52.60±3.1	18.20±1.3	18.00±2
Ce	69.20±3.0	59.70±3.0	28.50±15 ⁱⁱ	117.00±17	-	32.00±4
Pr	32.10±3.0	29.00±1.6	39.00±3 ⁱⁱ	43.80±2.0	-	12.10±0.4
Nm	1.10±0.1	5.4±0.39	9.43±0.4	9.25±0.51	2.20±0.3	2.10±0.07
Eu	1.10±0.10	1.05±0.08	1.9±0.12	(1.6)	552.00±35	550.00±30

Tb	0.8 _{-0.1}	0.405 _{-0.075}	-	(1.4)	0.4 _{-0.2} ^{###}	0.36 _{-0.12}
Dy	3.30 _{-1.5}	4.00 _{-1.0}	8.20 _{-1.3} [#]	7.46 _{-2.12}	2.0 _{-0.4} ^{###}	2.20 _{-0.3}
Yb	2.56 _{-0.4}	2.24 _{-0.2}	3.40 _{-0.4} [#]	3.42 _{-0.64}	-	0.98 _{-0.08}
Lu	0.39 _{-0.01}	0.330 _{-0.044}	0.48 _{-0.01} ^{##}	(0.54)	179.0 ₋₃₅ ^{###}	180.00 ₋₃₀
Zr	216.00 _{-20.0}	(221)	210.00 ₋₂₀ [#]	(241)	50.0 ₋₇ ^{###}	53.00 _{-5.0}
Hf	4.97 _{-0.9}	6.30 _{-0.3}	4.70 _{-0.7} [#]	4.16 _{-0.58}	2.0 _{-0.10}	1.55 _{-0.08}
Ta	0.91 _{-0.06}	0.704 _{-0.056}	-	(1.6)	380.0 ₋₄₀	400.00 ₋₃₀
	3.60 _{-0.50}	3.15 _{-0.45}	4.05 _{-0.4}	4.02 _{-0.32}	1.14 _{-0.06}	1.2 _{-0.1}
Th	14.70 _{-1.8}	11.3 _{-0.73}	12.30 _{-0.5}	14.00 _{-1.0}	4.20 _{-0.54}	4.8 _{-0.2}
Cl	-	-	-	(10)	890.00 ₋₈₀	790.0 ₋₂₀
I	-	(75)	23.00 _{-5.0}	(28)	1.50 _{-0.3}	1.8 _{-0.2}
Sr	3.50 _{-1.5}	5.4 _{-1.8}	7.00 _{-2.0} [#]	6.82 _{-1.73}	44.00 ₋₅ ^{###}	41.0 _{-4.0}
Ga	16.80 _{-2.0}	16.4 _{-1.6}	20.00 _{-4.0} ^{##}	(24)	7.50 _{-0.9} ^{###}	8.0 _{-0.8}
As	106.50 _{-3.0}	23.9 _{-7.5}	35.40 _{-4.0} ^{##}	27.5 _{-8.4}	12.0 _{-2.0}	10.2 _{-0.5}

Note:

- () - uncertified
- - The value was obtained by using the coal ash (1632a) and Lake Sediment (LK-1) as the standard.
- # - The value was obtained by using the IRLA's soil-5 and NBS Coal ash (1632a) as the standard.
- ### - The value was obtained by using the soil-5 and Lake Sediments (LK-1) as the standard.

Elements	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-10 cm	14-16 cm	18-20 cm
Co	0.30±0.03	0.39±0.04	0.43±0.04	0.49±0.05	0.54±0.06	0.56±0.07	0.63±0.07
Fe	-	-	-	-	-	-	-
Cr	3.44±0.65	3.49±0.65	3.50±0.65	3.51±0.65	3.95±0.60	2.87±0.70	2.40±0.90
Yb	-	3.07±0.50	3.09±0.50	3.07±0.50	3.05±0.50	-	6.74±2.50
Lu	1.04±0.20	1.07±0.21	1.10±0.21	1.09±0.21	1.11±0.19	1.65±0.20	0.69±0.10
Zr	289.20±20.0	300.0±20.0	300.0±20.0	300.0±20.0	300.0±20.0	350±5.00	385.00±30.0
Hf	3.80±3.00	3.80±3.00	3.80±3.00	3.80±3.00	3.80±3.00	10.50±4.0	10.19±3.58
Ra	-	-	-	-	-	-	-
U	13.50±1.80	13.50±1.80	13.50±1.80	13.70±1.80	13.51±1.60	13.80±1.50	15.90±1.70
Th	60.70±10.0	60.70±10.0	67.00±3.0	67.00±3.0	61.72±8.42	57.90±6.30	61.50±8.50
Cl	75.23±15.0	75.23±13.0	75.50±10.7	75.80±13.0	86.00±16.0	59.80±13.0	66.09±16.0
I	30.50±11.0	37.00±7.0	39.70±7.10	39.70±7.10	25.20±3.00	20.90±8.00	26.40±10.0
Br	15.40±1.70	16.00±1.90	10.50±3.00	10.70±3.00	19.09±2.13	18.05±2.00	18.09±2.00
Se	33.80±3.90	30.00±4.00	40.50±5.00	41.00±4.90	43.08±4.60	39.50±5.00	30.20±3.90
Ag	126.50±7.4	130.00±8.0	136.00±8.50	136.00±7.40	115.7±7.0	122.80±7.10	120.0±8.50

Table 6: Elemental contents in soil samples from station J.

Elements	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-10 cm	10-12 cm	12-14 cm	14-16 cm	16-18 cm
Ti	0.37±0.08	0.34±0.07	0.30±0.06	0.29±0.07	0.36±0.07	0.43±0.08	0.49±0.09	0.56±0.09	0.54±0.08
Al	3.80±0.40	3.52±0.40	3.31±0.40	2.11±0.20	2.96±0.30	5.13±0.50	5.74±0.60	5.72±0.60	6.86±0.08
Fe	1.61±0.09	2.82±0.13	1.09±0.06	1.70±0.06	1.01±0.14	1.45±0.05	1.49±0.05	1.69±0.08	1.81±0.05
Mg	0.58±0.10	0.63±0.12	0.73±0.15	0.67±0.10	0.76±0.15	0.84±0.20	1.03±0.40	0.93±0.30	0.88±0.25
Ca	-	-	-	-	-	-	-	-	-
Na	0.07±0.001	0.13±0.002	0.14±0.001	0.11±0.001	0.13±0.00	0.11±0.001	0.14±0.001	0.14±0.001	0.13±0.001
K	1.08±0.10	2.11±0.20	1.63±0.10	2.17±0.20	1.00±0.15	1.84±0.15	2.05±0.20	1.85±0.20	1.89±0.21
Mn	171.1±20.0	175.9±21.0	231.2±22.0	107.5±10.0	165.7±10.0	174.0±20.0	176.0±20.0	186.0±25.0	197.0±25.0
Si	8.17±0.37	13.70±0.63	11.10±0.70	10.24±0.03	14.11±0.75	9.25±0.61	9.75±0.62	10.79±0.49	11.07±0.73
V	76.7±5.00	77.4±6.50	77.7±5.20	60.5±6.10	79.11±9.10	107.9±10.0	126.9±10.5	120.5±12.0	118.2±11.5
Cr	76.61±15.0	79.27±20.0	77.04±15.0	71.8±15.0	77.50±15.0	31.04±5.0	47.40±6.0	58.90±6.80	68.90±7.50
Co	0.76±0.07	1.36±0.11	0.10±0.01	0.29±0.15	0.20±0.14	0.58±0.13	0.76±0.15	0.84±0.11	0.69±0.16
Cu	-	27.0±4.0	-	-	-	-	101.4±25.9	19.90±2.9	105.0±25.5
Sb	0.26±0.04	0.69±0.07	0.03±0.01	0.64±0.10	0.71±0.10	0.74±0.15	-	0.89±0.20	0.55±0.10
Bb	202.6±90.0	466.5±100	91.22±50.0	78.9±40.0	365.9±97.9	250.0±100.0	100.0±100.0	156.0±30.0	110.0±30.0
Cs	4.27±0.70	7.47±0.50	10.71±1.40	10.37±1.7	8.13±0.50	9.05±1.45	9.13±1.46	9.46±0.66	13.33±2.1
Ba	-	-	-	-	-	98.0±15.0	-	-	99.90±20.0
Sr	-	-	-	-	-	-	-	-	-
La	13.42±2.0	24.15±2.50	20.11±1.80	22.42±2.80	20.8±1.90	18.37±1.80	21.2±2.10	24.25±2.10	22.18±2.0
Ce	52.24±12.5	66.40±10.2	57.21±6.30	41.0±8.10	89.34±5.9	32.93±6.10	46.1±3.40	42.54±2.80	43.65±7.67
Pr	-	-	-	-	-	-	-	-	-
Sm	2.09±0.2	3.65±0.40	1.76±0.30	3.5±0.40	3.60±0.40	2.81±0.30	3.26±0.40	3.53±0.50	3.46±0.80

Elements	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-10 cm	10-12 cm	12-14 cm	14-16 cm	16-18 cm
Bu	0.37±0.04	0.69±0.07	0.33±0.04	0.60±0.07	0.66±0.29	0.28±0.02	0.44±0.03	0.62±0.06	0.54±0.24
Bp	0.53±0.25	0.59±0.35	—	0.66±0.29	—	—	—	—	0.66±0.24
Dy	3.07±0.65	3.09±0.81	3.20±0.15	3.39±0.54	3.67±0.81	3.28±0.31	4.36±0.40	3.36±0.60	3.81±0.50
Yb	4.27±2.07	5.55±0.40	4.51±0.10	5.50±3.00	5.50±3.00	5.60±3.00	—	2.37±1.00	2.62±1.07
Lu	0.18±0.03	0.26±0.14	0.25±0.13	0.29±0.03	0.35±0.04	0.41±0.05	0.48±0.07	0.55±0.10	0.45±0.09
Zr	275.5±30.0	277±20.00	3.02±0.10	3.02±0.10	3.75±30.0	—	234.0±30	—	281±20.8
Hf	8.98±2.50	10.95±1.50	1.17±0.10	4.09±1.11	13.40±1.07	4.73±1.01	—	6.78±0.55	5.29±1.06
Ta	1.60±0.48	1.78±0.40	1.50±0.75	1.56±0.74	1.37±0.69	2.23±0.64	1.82±0.51	1.41±0.41	1.31±0.13
U	—	—	—	—	—	—	—	—	—
Th	13.34±1.50	15.26±1.60	4.31±0.10	7.89±0.33	15.8±1.40	6.91±0.65	8.44±0.75	8.47±0.66	9.19±0.81
Pa	100.0±20.5	90.00±27.5	78.1±10.1	61.2±29.1	—	35.0±25.0	75.0±28.0	86.5±25.6	75.9±20.8
Pr	2.81±0.78	3.30±1.05	3.01±1.20	3.70±0.81	1.11±1.20	4.21±1.10	3.16±0.98	6.37±1.20	3.19±0.98
Sa	6.95±0.07	7.39±0.08	6.50±0.10	5.97±0.09	6.31±0.06	7.56±0.08	15.2±1.70	18.36±1.80	6.21±0.06
As	2.31±0.40	3.85±0.95	3.09±0.10	3.06±1.08	1.81±0.98	3.48±0.60	4.34±0.40	3.43±0.61	3.36±0.58

Table 3. Elemental composition of samples from station K.

<u>Elements</u>	<u>0-2 cm</u>	<u>2-4 cm</u>	<u>4-6 cm</u>	<u>6-10 cm</u>	<u>10-12 cm</u>	<u>12-14 cm</u>	<u>14-16 cm</u>	<u>16-18 cm</u>
Pi	0.19±0.05	0.09±0.03	0.07±0.03	0.04±0.03	0.04±0.03	0.30±0.03	0.32±0.05	0.31±0.05
Al	10.9±0.93	10.0±0.7	10.0±0.7	13.5±0.90	18.7±0.50	16.7±0.80	17.9±0.98	18.5±0.95
Fe	2.00±0.30	2.0±0.1	1.6±0.1	2.0±0.15	2.7±0.15	2.96±0.20	4.06±0.20	3.54±0.43
Mg	1.51±0.41	0.7±0.1	0.6±0.1	0.7±0.1	0.73±0.15	0.63±0.24	0.68±0.30	0.72±0.31
Cu	-	-	-	-	-	-	-	-
Na	0.06±0.005	0.07±0.005	0.07±0.005	0.07±0.005	0.08±0.006	0.07±0.004	0.07±0.004	0.02±0.005
K	1.39±0.13	1.0±0.1	1.0±0.1	1.0±0.13	0.97±0.20	0.89±0.19	1.35±0.20	1.38±0.25
Mn	327.0±25.0	121.0±30	117.0±30	110.0±24	345.0±37	268.0±27	320.0±28	350.0±30
Zn	2.04±0.30	1.5±0.1	1.3±0.1	1.3±0.14	15.7±1.87	16.7±1.8	19.7±1.30	13.2±1.23
V	16.50±2.5	1.9±0.2	2.0±0.2	1.40±0.37	23.60±3.4	24.15±3.0	25.3±3.50	24.3±4.00
Cr	-	-	-	-	-	-	-	-
Co	0.09±0.03	0.09±0.03	0.03±0.03	0.03±0.03	0.09±0.03	0.05±0.03	4.77±0.36	3.79±1.03
Zn	-	-	-	-	-	-	-	-
Pb	1.0±0.4	0.0±0.0	0.0±0.0	0.0±0.0	1.0±0.34	0.9±0.20	1.53±0.40	1.03±0.50
Rb	290.5±50	77.0±30	77.0±30	733.0±50	379.0±70	450.0±35	550.0±100	590.0±105
Cs	2.70±0.0	0.0±0.0	0.0±0.0	91.0±0.0	79.0±7.0	80.0±9.10	51.60±11.70	49.93±11.4?
Sr	19.0±1.50	0.0±0.0	0.0±0.0	1.0±8.00	79.0±7.0	80.0±1.60	97.0±9.70	95.79±3.50
Li	-	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	180.5±50.5	194.2±66.0
Ba	25.4±2.5	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	23.50±2.50	22.40±3.00
Mo	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	111.0±29.0	135.2±33.90
Ag	0.5±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	3.58±1.50	4.85±2.00
W	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.60±0.19	0.63±0.11

Elements	6-7 cm	7-8 cm	8-9 cm	9-10 cm	10-12 cm	12-14 cm	14-16 cm	16-19 cm
Eu	-	-	-	-	-	-	-	-
Tb	-	-	-	-	-	-	-	-
Dy	3.03±0.85	1.05±0.30	0.67±0.4	2.42±0.50	3.56±0.68	3.45±0.70	3.41±0.60	-
Yb	5.14±1.50	1.07±0.40	0.77±0.5	7.67±0.10	5.56±1.80	6.74±3.20	9.40±3.10	-
Lu	0.30±0.04	1.14±0.10	1.09±0.1	1.15±0.03	1.20±0.12	1.55±0.16	1.94±0.19	-
Zr	-	-	-	-	-	-	-	-
Hf	9.13±2.80	3.10±0.50	1.05±0.30	16.06±3.77	11.8±1.10	12.57±4.4	11.53±4.04	-
Ta	-	-	-	-	-	-	-	-
U	16.8±1.08	11.39±1.4	10.0±1.5	14.16±1.4	15.8±1.60	16.20±1.6	11.2±1.10	-
Th	53.6±9.80	59.4±9.0	60.00±9.5	61.91±8.63	71.08±9.8	83.90±11.56	85.78±12.2	-
Pa	77.9±15.8	73.7±17.1	80±4±17	-	80.70±12	98.00±16.00	90.8±15.10	-
I	12.8±4.80	13.05±5.1	11.9±1.8	17.73±7.1	15.70±7.3	16.80±5.8	17.8±6.20	-
-	22.5±2.00	17.70±2.	15.0±1.5	18.60±2.31	17.7±2.20	17.80±3.1	19.2±3.20	-
La	36.23±4.2	43.80±3.2	45.5±4.80	41.5±4.80	43.8±5.20	39.85±3.95	46.2±5.20	-
Ac	180.2±10.0	230.0±13	210.5±10	177.5±12	230.0±13	198±15.20	230±15.80	-

Table 2 : List of elements, radionuclides, possible interference and gamma ray selected for the analysis, data from ref. 1,8.

1. Short Irradiation (2-5 minutes)

Elements	Isotope	Half-life	α -energy selected (KeV)	Decay interval	Interference
Titanium	^{51}Ti	5.79m	320.0	<p>20minutes</p> <p>12-24 hours</p>	$^{30}\text{Si} (n, \alpha)$ $^{27}\text{Al} (n, p)$ $^{846}(\text{Mn}^{56})$ $^{31}\text{P} (n, \alpha)$ $^{28}\text{Si} (n, p)$ $^{24}\text{Mg} (n, p)$ $^{27}\text{Al} (n, \alpha)$ $^{56}\text{Fe} (n, p)$ $^{844} (^{27}\text{Mg})$ $^{559} (^{76}\text{As})$ $^{555} (^{82}\text{Br})$
Magnesium	^{27}Mg	9.46m	1014, 844		
Vanadium	^{52}V	3.75m	1434		
Aluminium	^{28}Al	2.32m	1779		
Sodium	^{24}Na	15.0h	1369, 2754		
Dysprosium	^{165}Dy	2.32h	95		
Iodine	^{128}I	25.0m	443		
Manganese	^{56}Mn	2.58h	1810, 2110, 846		
Calcium	^{49}Ca	8.8m	3084		
Chlorine	^{38}Cl	37.18m	1642, 2167		
Bromine	^{80}Br	17.60m	618		
Manganese	^{56}Mn	2.58h	1810, 2110, 846		
Sodium	^{24}Na	15.0h	1369, 2754		
Bromine	^{82}Br	35.34h	555, 775		
Gallium	^{72}Ga	14.10h	834		
Antimony	^{122}Sb	2.70d	564		
Arsenic	^{76}As	26.4h	559		
Samarium	^{153}Sm	46.8h	103		
Potassium	^{42}K	12.4h	1524		

continue from table 2

11. Long Irradiation (6 hours)

Elements	Isotope	Half-life	α -ray selected	Decay interval	Interference	
Europium	^{152}Eu	12.7y	122,1408		$^{177\text{m}}\text{Lu}(208)$ $^{177\text{m}}\text{Lu}(229)$	
Lutetium	^{177}Lu	5.74d	208			
Uranium	$^{239}\text{Np}(\text{U})$	56.5m	228,278			
Yterbium	^{131}Yb	4.21d	283,396			
Barium	^{131}Ba	12.1d	216,496			
Neodymium	^{147}Nd	11.1d	91,531			
Lanthanum	^{140}La	40.2h	816,1597			
Cerium	^{141}Ce	32.5d	146			$^{59}\text{Fe}(143)$
Rubidium	^{86}Rb	18.7d	1078			
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Europium	^{152}Eu	12.7y	122,1408		$^{160}\text{Tb}(300)$ $^{46}\text{Sc}(1120)$	
Tantalum	^{182}Ta	115d	1221			
Terbium	^{160}Tb	72.1d	880,966			
Thorium	$^{233}\text{Pa}(\text{Th})$	27.0d	312,300			
Chromium	^{51}Cr	27.8d	320			
Hafnium	^{181}Hf	42.5d	482			
Strontium	^{85}Sr	64.0d	514			
Zirconium	^{95}Zr	65.5d	757			
Scandium	^{46}Sc	83.9d	889,1120			
Iron	^{59}Fe	45.6d	1099,1292			
Zinc	^{65}Zn	243.0d	1116			
Cobalt	^{60}Co	5.26y	1173,1332			
Caesium	^{134}Cs	2.06y	604,796			

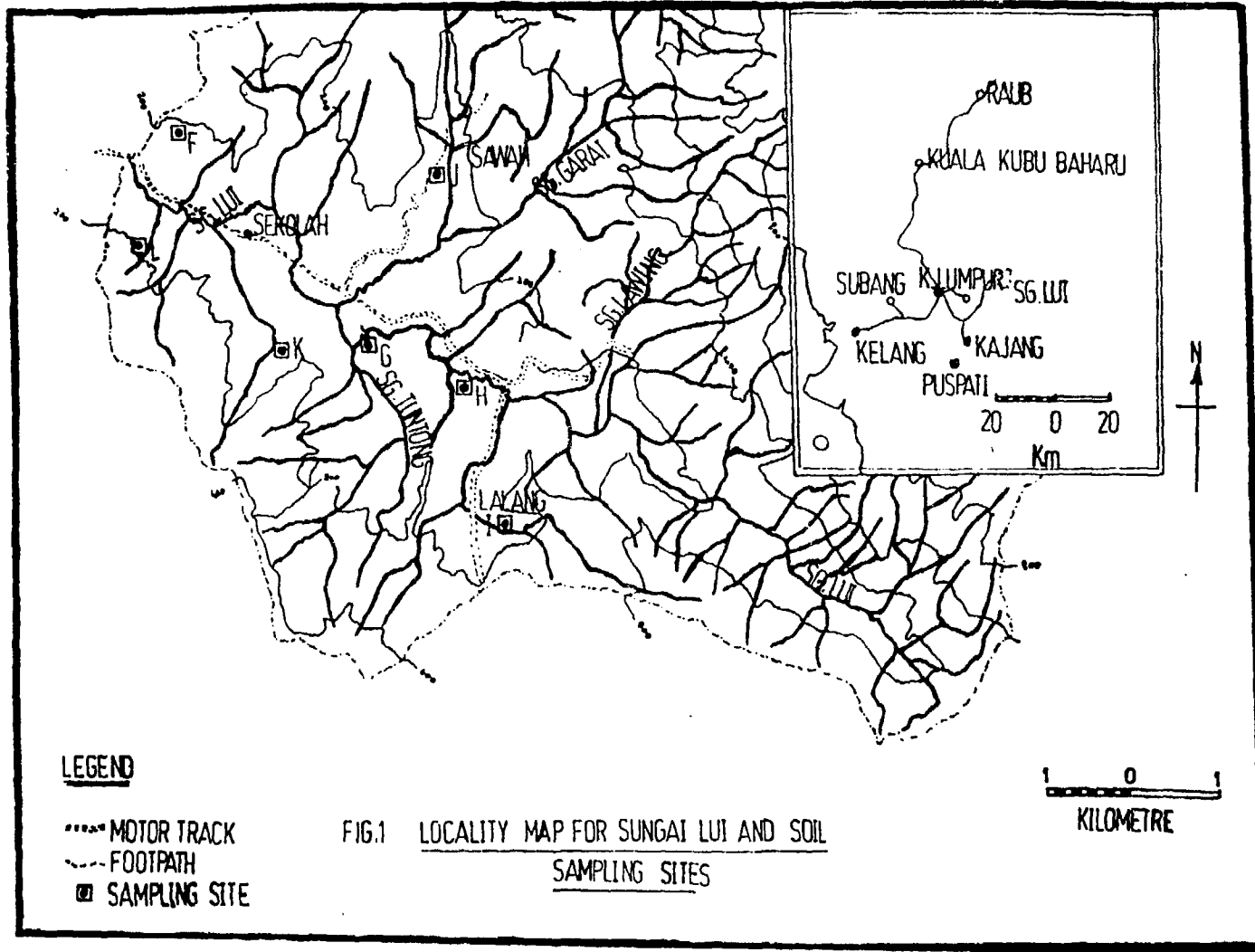
Table 3 : Interference from the (n,p) and (n,α) reaction.

Nuclear reaction	Radionuclide interfered	Contribution in mg/g isotop
^{28}Si (n,p) ^{28}Al	^{28}Al	3.292 mg
^{31}P (n,α) ^{28}Al	^{28}Al	N.D. *
^{27}Al (n,p) ^{27}Mg	^{27}Mg	279.2 mg
^{31}Si (n,α) ^{27}Mg	^{27}Mg	low (undetected)
^{24}Mg (n,p) ^{24}Na	^{24}Na	1.48 mg
^{27}Al (n,α) ^{24}Na	^{24}Na	low (undetected)
^{56}Fe (n,p) ^{56}Mn	^{56}Mn	0.157 mg

Key to table :- N.D. *, not determined.

Table 4 : Elemental contents form soils at station J, I, G, K and G, around Sungai Lui's area, Kajang, Selangor (samples were taken at 22-24 cm depths)

Elements	F	G	J	I	K
Ti	0.31±0.03	0.43±0.04	0.55±0.09	0.39±0.09	0.35±0.05
Al	11.9±0.9	6.15±0.70	7.15±0.80	9.36±0.90	19.5±0.95
Fe	2.29±0.30	2.84±0.40	2.90±0.18	2.34±0.20	3.08±0.43
Mg	1.51±0.50	0.89±0.60	0.86±0.25	1.15±0.30	0.81±0.31
Ca	-	-	-	-	-
Na	0.06±0.005	0.07±0.005	0.13±0.001	0.03±0.001	0.08±0.006
K	1.31±0.50	0.77±0.48	1.48±0.21	0.41±0.09	1.58±0.31
Mn	227±29.0	212.0±25.0	194.0±25	179.0±23.0	380.0±30.5
Sc	9.64±0.75	8.82±0.80	12.40±0.80	6.72±0.70	19.20±1.25
U	17.6±2.0	57.9±6.2	115.0±11.5	52.5±5.3	24.0±4.0
Cr	7.36±3.2	33.94±5.5	80.11±7.5	29.8±2.5	3.8±0.12
Co	1.75±0.18	1.69±0.17	1.49±0.18	2.23±0.22	4.10±1.21
Zn	47.06±10.1	38.5±8.5	61.91±20.2	49.8±8.8	38.5±10.8
Sb	1.85±0.20	1.55±0.20	1.07±0.20	0.48±0.18	1.55±0.30
Rb	255.3±50.0	85.13±20.8	106.6±28.5	48.2±12.5	598±80.5
Cs	21.4±6.8	17.60±5.8	8.79±1.8	7.47±2.5	60.5±15.3
Ba	-	126.2±25.0	157.5±21.0	-	84.8±10.0
Sr	-	-	-	-	-
La	20.9±2.1	20.14±2.0	20.1±2.0	21.2±2.0	25.0±2.5
Ce	50.2±20.1	50.70±7.8	42.0±6.8	40.12±7.5	125.0±30.8
Nd	-	-	-	-	-
Sm	4.23±0.21	3.2±0.18	4.23±0.91	3.16±0.85	4.95±2.5
Eu	0.65±0.08	0.75±0.09	0.56±0.04	0.54±0.05	0.58±0.21
Tb	-	-	-	-	0.19±0.05
Dy	3.44±0.95	2.44±0.50	3.44±0.48	2.54±0.50	3.45±0.61
Yb	5.76±2.1	2.81±2.1	5.76±1.50	2.19±0.75	8.91±3.5
Lu	0.45±0.15	0.39±0.15	0.37±0.09	0.30±0.09±	0.98±0.09
Zr	390.0±30.0	389.0±25.0	278.7±25.0	328.1±30.0	427.0±28.0
Hf	10.01±4.0	9.83±3.7	6.47±1.25	7.02±2.8	9.46±2.1
Ta	-	-	1.65±0.20	-	-
U	13.5±1.8	3.76±0.98	-	10.0±1.0	16.8±2.1
Th	51.90±7.8	27.06±5.8	10.80±0.85	45.5±7.8	53.8±9.1
Cl	57.5±13.0	70.2±15.0	80.0±40.1	78.0±30.0	80.9±20.1
Br	19.07±2.5	25.19±1.8	6.32±1.20	26.12±2.0	15.8±6.2
I	40.0±10.5	-	-	-	28.8±7.1
As	91.9±5.8	63.04±6.8	6.45±0.61	18.07±2.1	180.0±20.0
Ga	39.5±3.8	14.90±0.15	6.21±0.06	25.8±0.18	24.8±4.1

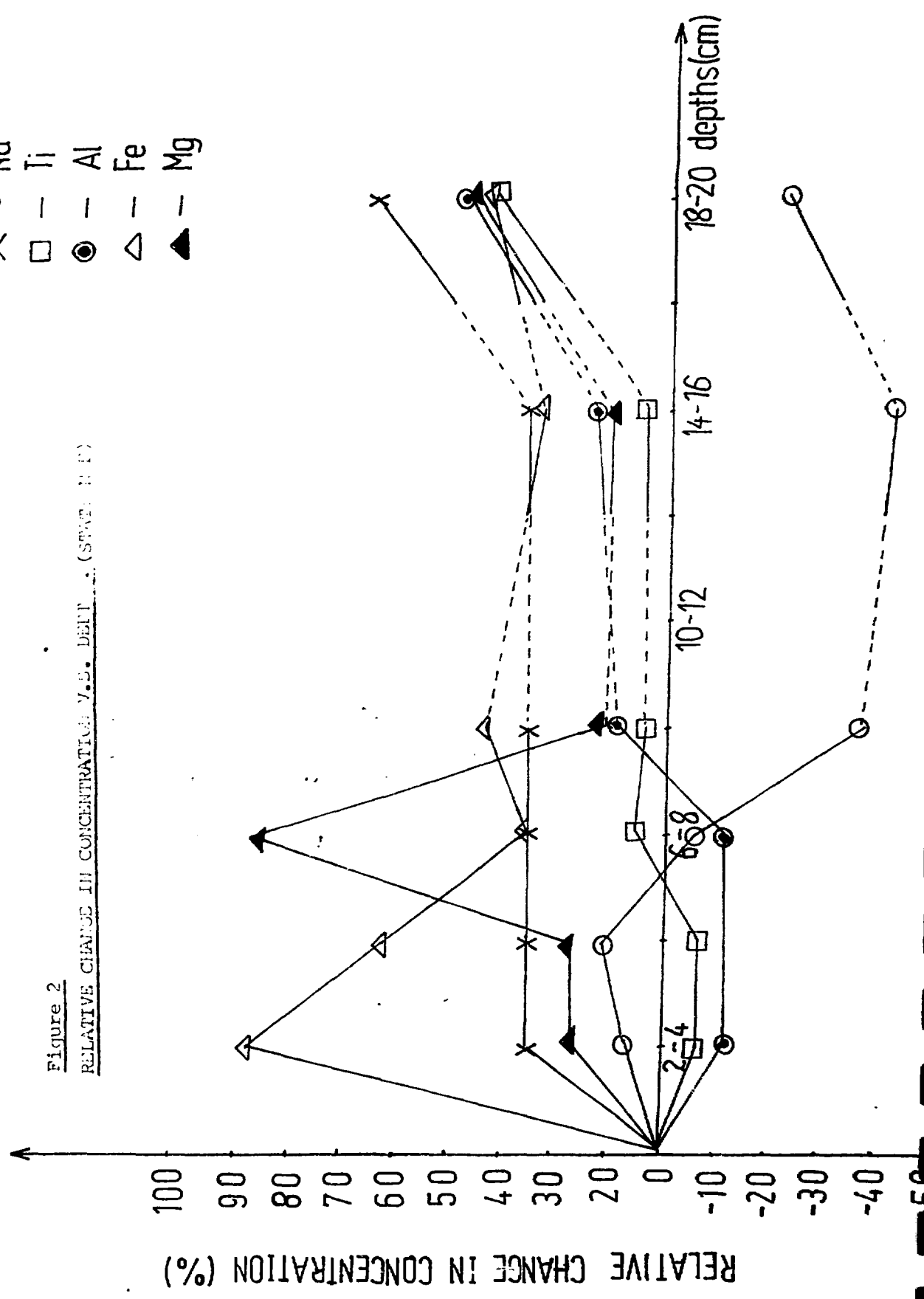


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Figure 2
 RELATIVE CHANGE IN CONCENTRATION V.S. DEPTH (STATION H.P.)



- - K
- ⊙ - Al
- × - Na
- △ - Fe
- - Ti
- ▲ - Mg

Figure 3
RELATIVE CHANGE IN CONCENTRATION V.S. DEPTH (CONTINUED)

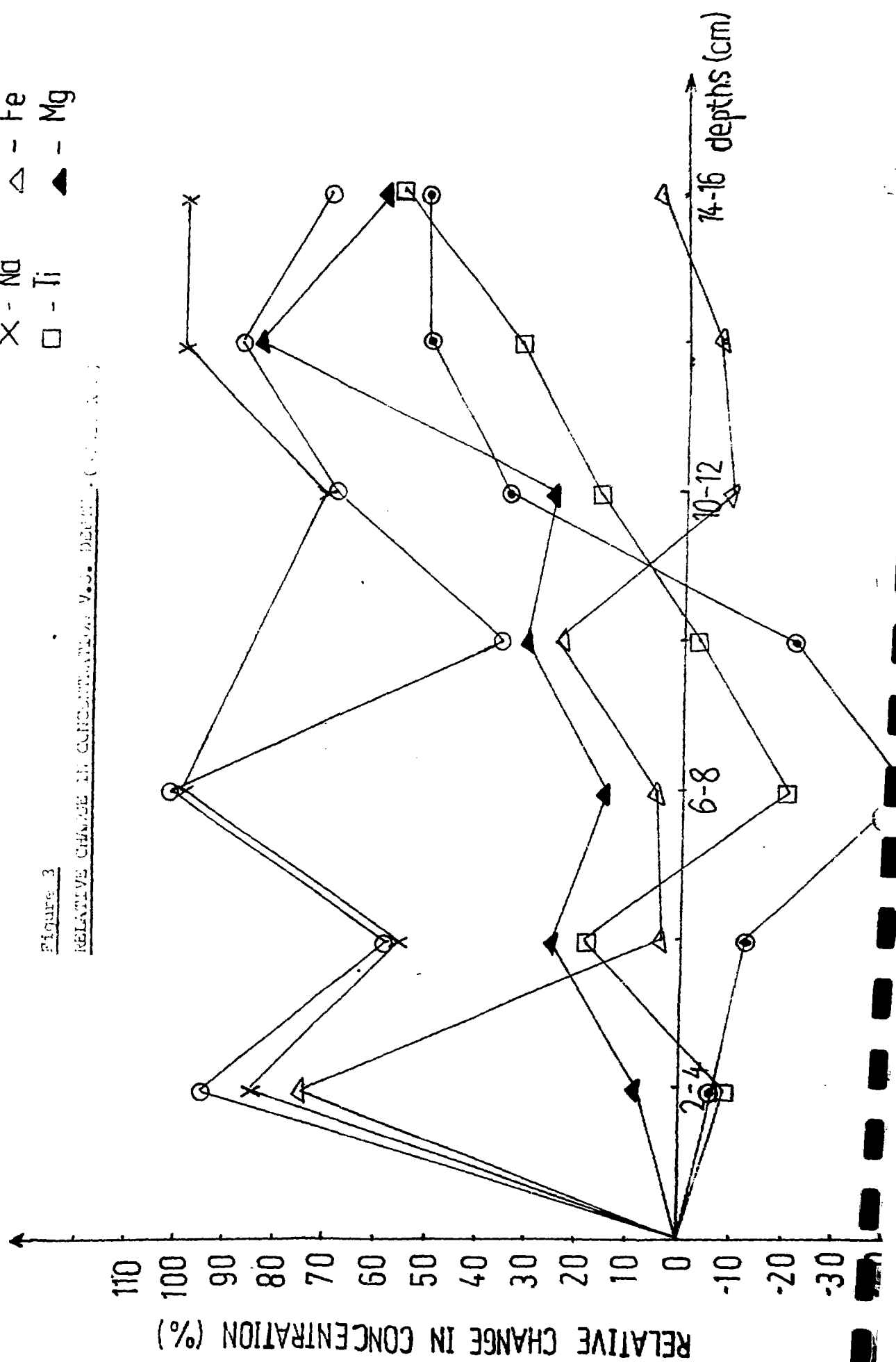


Figure 4

RELATIVE CHANGE IN CONCENTRATION V.S. DEPTH (STATION 16)

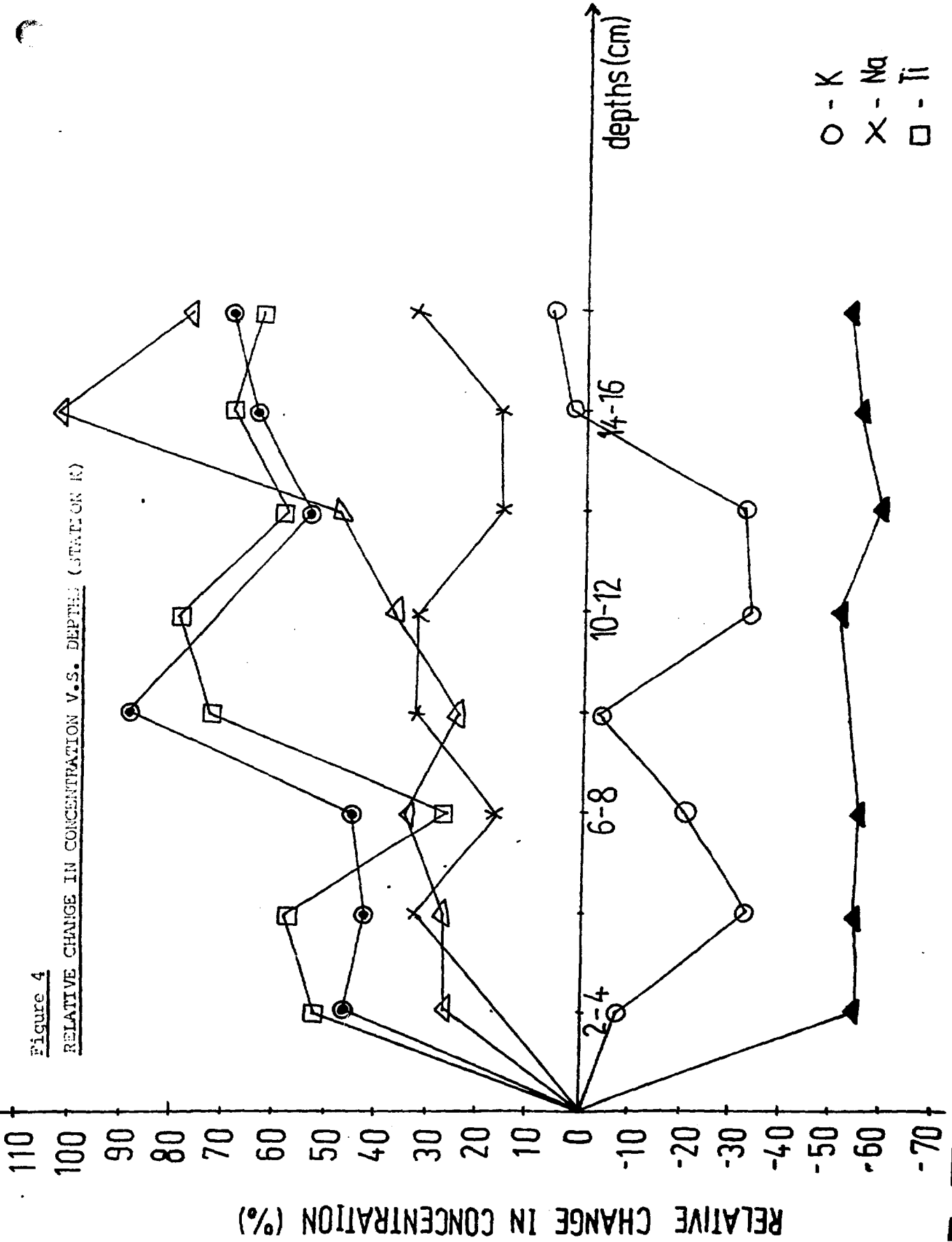


Table 6: Elemental contents in soil samples from station J.

Elements	0-2 cm	2-4 cm	4-6 cm	6-8 cm	9-10 cm	10-12 cm	12-14 cm	14-16 cm	16-18 cm
Ti	0.37±0.08	0.34±0.07	0.30±0.06	0.29±0.07	0.36±0.07	0.43±0.08	0.49±0.09	0.56±0.09	0.54±0.08
Al	3.80±0.40	3.52±0.40	3.31±0.40	3.11±0.40	3.96±0.40	5.13±0.50	5.74±0.60	5.72±0.60	6.26±0.08
Fe	1.61±0.09	2.82±0.13	1.09±0.06	1.70±0.06	2.01±0.14	1.45±0.05	1.49±0.05	1.69±0.08	1.81±0.05
Mg	0.58±0.10	0.63±0.12	0.73±0.15	0.67±0.10	0.76±0.15	0.84±0.20	1.08±0.40	0.93±0.30	0.88±0.25
Ca	-	-	-	-	-	-	-	-	-
Na	0.07±0.001	0.13±0.002	0.11±0.001	0.14±0.001	0.13±0.001	0.12±0.001	0.11±0.001	0.14±0.001	0.13±0.001
K	1.08±0.10	2.11±0.10	1.03±0.20	1.17±0.20	1.43±0.15	1.84±0.15	2.05±0.20	1.85±0.20	1.98±0.21
Mn	171.1±20.0	175.9±20.0	171.1±20.0	161.5±20.0	180±20.0	174.0±20.0	176.0±20.0	185.0±25.0	197.0±25.0
Si	8.17±0.37	13.70±0.63	11.1±0.70	10.94±0.08	14.1±0.75	9.25±0.61	9.25±0.62	10.79±0.49	11.07±0.73
V	76.7±5.00	77.4±0.50	82.5±5.90	82.5±6.10	79.11±8.10	107.8±10.0	126.9±10.5	120.5±12.0	118.2±11.5
Cr	76.61±15.0	79.2±20.0	71.8±15.0	71.8±15.0	77.50±15.0	31.04±5.0	42.40±6.0	58.90±6.80	68.90±7.50
Co	0.76±0.07	1.36±0.13	0.41±0.10	0.39±0.15	0.40±0.14	0.58±0.13	0.76±0.15	0.84±0.11	0.69±0.16
Zn	-	27.6±4.0	-	-	-	-	101.4±25.9	19.90±2.9	105.0±25.5
Sb	0.26±0.04	0.09±0.07	0.23±0.08	0.04±0.10	0.71±0.10	0.74±0.15	-	0.89±0.20	0.55±0.10
Bb	102.0±30.0	466.5±140	31.27±50.0	78.9±4.0	366.3±97.0	250.0±100.0	160.0±11.0	156.0±30.0	110.0±30.0
Cs	4.87±0.70	7.47±1.50	16.71±1.70	10.31±1.7	6.13±0.50	9.05±1.45	9.13±1.46	9.46±0.66	13.33±2.1
Ba	-	-	-	-	-	36.0±15.0	-	-	99.90±20.0
Jr	-	-	-	-	-	-	-	-	-
Lu	13.42±2.0	14.15±1.0	16.41±1.80	2.4±2.80	20.8±1.30	18.37±1.80	11.2±2.10	24.25±2.10	22.18±2.0
Ce	52.24±12.5	56.40±10.2	51.71±6.30	41.9±8.10	39.34±5.9	32.93±6.10	46.1±3.40	42.54±2.80	43.65±7.67
Pr	-	-	-	-	-	-	-	-	-
Sm	0.02±0.2	3.62±0.40	0.72±0.30	3.5±0.40	5.50±0.40	2.81±0.30	3.26±0.40	3.53±0.50	3.46±0.80

Elements	0-4 cm	4-8 cm	8-12 cm	12-16 cm	16-20 cm	20-24 cm	24-28 cm	28-32 cm	32-36 cm	36-40 cm	40-44 cm	44-48 cm	48-52 cm	52-56 cm	56-60 cm	60-64 cm	64-68 cm	68-72 cm	72-76 cm	76-80 cm	80-84 cm	84-88 cm	88-92 cm	92-96 cm	96-100 cm																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
Su	0.37±0.04	0.62±0.07	0.91±0.11	1.24±0.16	1.61±0.21	2.02±0.26	2.47±0.31	2.96±0.36	3.49±0.41	4.06±0.46	4.67±0.51	5.31±0.56	5.98±0.61	6.67±0.66	7.38±0.71	8.11±0.76	8.86±0.81	9.62±0.86	10.39±0.91	11.17±0.96	11.96±1.01	12.76±1.06	13.57±1.11	14.38±1.16	15.20±1.21	16.03±1.26	16.87±1.31	17.72±1.36	18.58±1.41	19.45±1.46	20.33±1.51	21.22±1.56	22.12±1.61	23.03±1.66	23.95±1.71	24.88±1.76	25.82±1.81	26.77±1.86	27.73±1.91	28.70±1.96	29.68±2.01	30.67±2.06	31.67±2.11	32.68±2.16	33.70±2.21	34.73±2.26	35.77±2.31	36.82±2.36	37.88±2.41	38.95±2.46	39.03±2.51	40.12±2.56	41.22±2.61	42.33±2.66	43.45±2.71	44.58±2.76	45.72±2.81	46.87±2.86	48.03±2.91	49.20±2.96	50.38±3.01	51.57±3.06	52.77±3.11	53.98±3.16	55.20±3.21	56.43±3.26	57.67±3.31	58.92±3.36	60.18±3.41	61.45±3.46	62.73±3.51	64.02±3.56	65.32±3.61	66.63±3.66	67.95±3.71	69.28±3.76	70.62±3.81	71.97±3.86	73.33±3.91	74.70±3.96	76.08±4.01	77.47±4.06	78.87±4.11	80.28±4.16	81.70±4.21	83.13±4.26	84.57±4.31	86.02±4.36	87.48±4.41	88.95±4.46	90.43±4.51	91.92±4.56	93.42±4.61	94.93±4.66	96.45±4.71	97.98±4.76	99.52±4.81	101.07±4.86	102.63±4.91	104.20±4.96	105.78±5.01	107.37±5.06	108.97±5.11	110.58±5.16	112.20±5.21	113.83±5.26	115.47±5.31	117.12±5.36	118.78±5.41	120.45±5.46	122.13±5.51	123.82±5.56	125.52±5.61	127.23±5.66	128.95±5.71	130.68±5.76	132.42±5.81	134.17±5.86	135.93±5.91	137.70±5.96	139.48±6.01	141.27±6.06	143.07±6.11	144.88±6.16	146.70±6.21	148.53±6.26	150.37±6.31	152.22±6.36	154.08±6.41	155.95±6.46	157.83±6.51	159.72±6.56	161.62±6.61	163.53±6.66	165.45±6.71	167.38±6.76	169.32±6.81	171.27±6.86	173.23±6.91	175.20±6.96	177.18±7.01	179.17±7.06	181.17±7.11	183.18±7.16	185.20±7.21	187.23±7.26	189.27±7.31	191.32±7.36	193.38±7.41	195.45±7.46	197.53±7.51	199.62±7.56	201.72±7.61	203.83±7.66	205.95±7.71	208.08±7.76	210.22±7.81	212.37±7.86	214.53±7.91	216.70±7.96	218.88±8.01	221.07±8.06	223.27±8.11	225.48±8.16	227.70±8.21	229.93±8.26	232.17±8.31	234.42±8.36	236.68±8.41	238.95±8.46	241.23±8.51	243.52±8.56	245.82±8.61	248.13±8.66	250.45±8.71	252.78±8.76	255.12±8.81	257.47±8.86	259.83±8.91	262.20±8.96	264.58±9.01	266.97±9.06	269.37±9.11	271.78±9.16	274.20±9.21	276.63±9.26	279.07±9.31	281.52±9.36	283.98±9.41	286.45±9.46	288.93±9.51	291.42±9.56	293.92±9.61	296.43±9.66	298.95±9.71	301.48±9.76	304.02±9.81	306.57±9.86	309.13±9.91	311.70±9.96	314.28±10.01	316.87±10.06	319.47±10.11	322.08±10.16	324.70±10.21	327.33±10.26	330.00±10.31	332.68±10.36	335.38±10.41	338.09±10.46	340.81±10.51	343.54±10.56	346.28±10.61	349.03±10.66	351.79±10.71	354.56±10.76	357.34±10.81	360.13±10.86	362.93±10.91	365.74±10.96	368.56±11.01	371.39±11.06	374.23±11.11	377.08±11.16	379.94±11.21	382.81±11.26	385.69±11.31	388.58±11.36	391.48±11.41	394.39±11.46	397.31±11.51	400.24±11.56	403.18±11.61	406.13±11.66	409.09±11.71	412.06±11.76	415.04±11.81	418.03±11.86	421.03±11.91	424.04±11.96	427.06±12.01	430.09±12.06	433.13±12.11	436.18±12.16	439.24±12.21	442.31±12.26	445.39±12.31	448.48±12.36	451.58±12.41	454.69±12.46	457.81±12.51	460.94±12.56	464.08±12.61	467.23±12.66	470.39±12.71	473.56±12.76	476.74±12.81	479.93±12.86	483.13±12.91	486.34±12.96	489.56±13.01	492.79±13.06	496.03±13.11	499.28±13.16	502.54±13.21	505.81±13.26	509.09±13.31	512.38±13.36	515.68±13.41	518.99±13.46	522.31±13.51	525.64±13.56	528.98±13.61	532.33±13.66	535.69±13.71	539.06±13.76	542.44±13.81	545.83±13.86	549.23±13.91	552.64±13.96	556.06±14.01	559.49±14.06	562.93±14.11	566.38±14.16	569.84±14.21	573.31±14.26	576.79±14.31	580.28±14.36	583.78±14.41	587.29±14.46	590.81±14.51	594.34±14.56	597.88±14.61	601.43±14.66	604.99±14.71	608.56±14.76	612.14±14.81	615.73±14.86	619.33±14.91	622.94±14.96	626.56±15.01	630.19±15.06	633.83±15.11	637.48±15.16	641.14±15.21	644.81±15.26	648.49±15.31	652.18±15.36	655.88±15.41	659.59±15.46	663.31±15.51	667.04±15.56	670.78±15.61	674.53±15.66	678.29±15.71	682.06±15.76	685.84±15.81	689.63±15.86	693.43±15.91	697.24±15.96	701.06±16.01	704.89±16.06	708.73±16.11	712.58±16.16	716.44±16.21	720.31±16.26	724.19±16.31	728.08±16.36	731.98±16.41	735.89±16.46	739.81±16.51	743.74±16.56	747.68±16.61	751.63±16.66	755.59±16.71	759.56±16.76	763.54±16.81	767.53±16.86	771.53±16.91	775.54±16.96	779.56±17.01	783.59±17.06	787.63±17.11	791.68±17.16	795.74±17.21	799.81±17.26	803.89±17.31	807.98±17.36	812.08±17.41	816.19±17.46	820.31±17.51	824.44±17.56	828.58±17.61	832.73±17.66	836.89±17.71	841.06±17.76	845.24±17.81	849.43±17.86	853.63±17.91	857.84±17.96	862.06±18.01	866.29±18.06	870.53±18.11	874.78±18.16	879.04±18.21	883.31±18.26	887.59±18.31	891.88±18.36	896.18±18.41	900.49±18.46	904.81±18.51	909.14±18.56	913.48±18.61	917.83±18.66	922.09±18.71	926.36±18.76	930.64±18.81	934.93±18.86	939.23±18.91	943.54±18.96	947.86±19.01	952.19±19.06	956.53±19.11	960.88±19.16	965.24±19.21	969.61±19.26	973.99±19.31	978.38±19.36	982.78±19.41	987.19±19.46	991.61±19.51	996.04±19.56	1000.48±19.61	1004.93±19.66	1009.39±19.71	1013.86±19.76	1018.34±19.81	1022.83±19.86	1027.33±19.91	1031.84±19.96	1036.36±20.01	1040.89±20.06	1045.43±20.11	1049.98±20.16	1054.54±20.21	1059.11±20.26	1063.69±20.31	1068.28±20.36	1072.88±20.41	1077.49±20.46	1082.11±20.51	1086.74±20.56	1091.38±20.61	1096.03±20.66	1100.69±20.71	1105.36±20.76	1109.04±20.81	1113.73±20.86	1118.43±20.91	1123.14±20.96	1127.86±21.01	1132.59±21.06	1137.33±21.11	1142.08±21.16	1146.84±21.21	1151.61±21.26	1156.39±21.31	1161.18±21.36	1165.98±21.41	1170.79±21.46	1175.61±21.51	1180.44±21.56	1185.28±21.61	1190.13±21.66	1194.99±21.71	1200.86±21.76	1205.74±21.81	1210.63±21.86	1215.53±21.91	1220.44±21.96	1225.36±22.01	1230.29±22.06	1235.23±22.11	1240.18±22.16	1245.14±22.21	1250.11±22.26	1255.09±22.31	1260.08±22.36	1265.08±22.41	1270.09±22.46	1275.11±22.51	1280.14±22.56	1285.18±22.61	1290.23±22.66	1295.29±22.71	1300.36±22.76	1305.44±22.81	1310.53±22.86	1315.63±22.91	1320.74±22.96	1325.86±23.01	1330.99±23.06	1336.13±23.11	1341.28±23.16	1346.44±23.21	1351.61±23.26	1356.79±23.31	1361.98±23.36	1367.18±23.41	1372.39±23.46	1377.61±23.51	1382.84±23.56	1388.08±23.61	1393.33±23.66	1398.59±23.71	1403.86±23.76	1409.14±23.81	1414.43±23.86	1419.73±23.91	1425.04±23.96	1430.36±24.01	1435.69±24.06	1441.03±24.11	1446.38±24.16	1451.74±24.21	1457.11±24.26	1462.49±24.31	1467.88±24.36	1473.28±24.41	1478.69±24.46	1484.11±24.51	1489.54±24.56	1494.98±24.61	1500.43±24.66	1505.89±24.71	1511.36±24.76	1516.84±24.81	1522.33±24.86	1527.83±24.91	1533.34±24.96	1538.86±25.01	1544.39±25.06	1549.93±25.11	1555.48±25.16	1561.04±25.21	1566.61±25.26	1572.19±25.31	1577.78±25.36	1583.38±25.41	1588.99±25.46	1594.61±25.51	1600.24±25.56	1605.88±25.61	1611.53±25.66	1617.19±25.71	1622.86±25.76	1628.54±25.81	1634.23±25.86	1639.93±25.91	1645.64±25.96	1651.36±26.01	1657.09±26.06	1662.83±26.11	1668.58±26.16	1674.34±26.21	1680.11±26.26	1685.89±26.31	1691.68±26.36	1697.48±26.41	1703.29±26.46	1709.11±26.51	1714.94±26.56	1720.78±26.61	1726.63±26.66	1732.49±26.71	1738.36±26.76	1744.24±26.81	1750.13±26.86	1756.03±26.91	1761.94±26.96	1767.86±27.01	1773.79±27.06	1779.73±27.11	1785.68±27.16	1791.64±27.21	1797.61±27.26	1803.59±27.31	1809.58±27.36	1815.58±27.41	1821.59±27.46	1827.61±27.51	1833.64±27.56	1839.68±27.61	1845.73±27.66	1851.79±27.71	1857.86±27.76	1863.94±27.81	1870.03±27.86	1876.13±27.91	1882.24±27.96	1888.36±28.01	1894.49±28.06	1900.63±28.11	1906.78±28.16	1912.94±28.21	1919.11±28.26	1925.29±28.31	1931.48±28.36	1937.68±28.41	1943.89±28.46	1950.11±28.51	1956.34±28.56	1962.58±28.61	1968.83±28.66	1975.09±28.71	1981.36±28.76	1987.64±28.81	1993.93±28.86	2000.23±28.91	2006.54±28.96	2012.86±29.01	2019.19±29.06	2025.53±29.11	2031.88±29.16	2038.24±29.21	2044.61±29.26	2050.99±29.31	2057.38±29.36	2063.78±29.41	2070.19±29.46	2076.61±29.51	2083.04±29.56	2089.48±29.61	2095.93±29.66	2102.39±29.71	2108.86±29.76	2115.34±29.81	2121.83±29.86	2128.33±29.91	2134.84±29.96	2141.36±30.01	2147.89±30.06	2154.43±30.11	2160.98±30.16	2167.54±30.21	2174.11±30.26	2180.69±30.31	2187.28±30.36	2193.88±30.41	2200.49±30.46	2207.11±30.51	2213.74±30.56	2220.38±30.61	2227.03±30.66	2233.69±30.71	2240.36±30.76	2247.04±30.81	2253.73±30.86	2260.43±30.91	2267.14±30.96	2273.86±31.01	2280.59±31.06	2287.33±31.11	2294.08±31.16	2300.84±31.21	2307.61±31.26	2314.39±31.31	2321.18±31.36	2327.98±31.41	2334.79±31.46	2341.61±31.51	2348.44±31.56	2355.28±31.61	2362.13±31.66	2369.00±31.71	2375.88±31.76	2382.77±31.81	2389.67±31.86	2396.58±31.91	2403.50±31.96	2410.43±32.01	2417.37±32.06	2424.32±32.11	2431.28±32.16	2438.25±32.21	2445.23±32.26	2452.22±32.31	2459.22±32.36	2466.23±32.41	2473.25±32.46	2480.28±32.51	2487.32±32.56	2494.37±32.61	2501.43±32.66	2508.50±32.71	2515.58±32.76	2522.67±32.81	2529.77±32.86	2536.88±32.91	2543.99±32.96	2551.11±33.01	2558.24±33.06	2565.38±33.11	2572.53±33.16	2579.69±33.21	2586.86±33.26	2594.04±33.31	2601.23±33.36	2608.43±33.41	2615.64±33.46

Table 3. Calculated relative intensities from 5000 to 10000 K.

Elements	0-2 cm	2-4 cm	4-6 cm	6-10 cm	10-12 cm	12-14 cm	14-16 cm	16-18 cm
Ti	0.19±0.05	0.07±0.03	0.02±0.01	0.01±0.01	0.03±0.03	0.25±0.03	0.32±0.05	0.31±0.05
Al	10.9±0.03	10.0±0.07	10.0±0.07	10.0±0.06	18.7±0.30	16.7±0.90	17.9±0.98	18.5±0.95
Si	2.00±0.20	0.01±0.01	0.01±0.01	0.01±0.01	3.35±0.31	2.96±0.20	4.06±0.20	3.53±0.43
Mg	1.51±0.44	0.01±0.01	0.01±0.01	0.68±0.14	0.73±0.10	0.63±0.24	0.63±0.30	0.72±0.31
Cu	-	-	-	-	-	-	-	-
Ca	0.06±0.005	0.07±0.01	0.07±0.01	0.07±0.01	0.02±0.006	0.07±0.004	0.07±0.004	0.02±0.000
K	1.30±0.13	0.01±0.01	0.01±0.01	1.04±0.13	0.17±0.20	0.89±0.19	1.35±0.20	1.39±0.25
Na	327.2±25.0	32.0±3.5	32.0±3.5	31.0±3.4	315.0±37	268.0±27	320.0±28	350.0±30
Sc	2.04±0.30	0.01±0.01	0.01±0.01	13.60±0.13	15.79±1.07	16.78±1.8	19.7±1.30	18.2±1.23
V	10.50±2.5	0.9±0.0	0.9±0.0	0.9±0.0	23.60±3.70	24.15±3.0	25.3±3.50	24.8±4.00
Zr	-	-	-	-	-	-	-	-
Co	0.00±0.00	0.01±0.01	0.01±0.01	0.01±0.01	2.18±0.69	2.25±0.70	4.77±0.96	3.73±1.03
Zn	-	-	-	-	-	-	-	-
Zn	1.01±0.45	0.01±0.01	0.01±0.01	0.01±0.01	1.80±0.38	0.39±0.20	1.98±0.40	1.03±0.50
Fe	200.0±10	77.0±10	77.0±10	73.0±10	179.0±10	490.0±10	550.0±100	530.0±100
Os	21.7±0.0	0.01±0.01	0.01±0.01	0.01±0.01	73.0±7.00	60.0±3.10	51.60±11.70	49.35±11.43
Be	0.01±0.01	0.01±0.01	0.01±0.01	0.01±0.01	79.0±7.00	66.0±1.60	97.0±9.70	95.75±3.50
Br	0.01±0.01	0.01±0.01	0.01±0.01	0.01±0.01	96.5±30.3	101.0±35.0	140.5±50.5	194.2±60.0
Li	0.04±0.01	0.01±0.01	0.01±0.01	0.01±0.01	2.06±3.0	1.36±2.1	23.50±2.50	22.10±1.00
Se	34.00±1.5	0.01±0.01	0.01±0.01	0.01±0.01	9.1±27.0	38.0±25.0	111.0±29.0	135.2±33.90
Mo	0.01±0.01	0.01±0.01	0.01±0.01	0.01±0.01	0.01±1.00	0.07±1.50	3.53±1.50	4.85±2.00
W	0.01±0.01	0.01±0.01	0.01±0.01	0.01±0.01	0.05±0.25	0.09±0.18	0.60±0.19	0.63±0.21

<u>Elements</u>	<u>0-2 cm</u>	<u>2-4 cm</u>	<u>4-6 cm</u>	<u>6-8 cm</u>	<u>8-10 cm</u>	<u>10-12cm</u>	<u>12-14 cm</u>	<u>14-16 cm</u>	<u>16-18 cm</u>
Eu	-	-	-	-	-	-	-	-	-
Tb	-	-	-	-	-	-	-	-	-
Dy	3.03±0.55	-	0.01±0.02	1.07±0.14	2.47±0.50	3.56±0.68	3.45±0.70	3.41±0.65	-
Yb	5.14±1.50	5.71±2.10	5.71±1.10	6.37±3.5	7.47±4.10	5.56±1.80	6.74±3.20	9.46±3.1	-
Lu	0.30±0.04	1.11±0.16	0.91±0.1	1.39±0.13	1.19±0.12	1.70±0.12	1.55±0.16	1.94±0.19	-
Zr	-	-	-	-	-	-	-	-	-
Hf	9.43±2.80	3.40±3.50	3.95±0.70	4.14±3.3	10.05±3.77	10.01±3.7	11.8±4.10	12.57±4.4	11.53±4.04
Ta	-	-	-	-	-	-	-	-	-
U	16.8±1.08	11.39±1.13	13.00±1.4	15.01±1.5	15.5±1.6	14.16±1.4	15.8±1.60	16.20±1.6	11.2±1.10
Th	53.6±9.30	59.4±9.0	61.3±9.0	60.80±8.5	61.91±8.63	71.08±9.8	65.3±10.0	83.90±11.56	89.58±12.3
Pa	77.9±15.8	73.7±17.1	73.1±17	66.4±17	-	60.70±12	75.9±15.0	98.00±16.00	90.8±15.10
I	12.8±4.80	13.0±4.7	13.6±4.8	17.73±7.1	17.70±7.1	18.70±7.3	15.3±6.10	16.80±5.8	17.8±6.20
Pr	23.8±2.50	17.70±2.0	17.6±2.5	16.73±2.9	16.60±2.31	17.7±2.20	18.2±2.80	17.80±3.1	19.2±3.20
Sm	36.1±4.2	33.70±4.1	34.1±4.0	31.5±4.80	41.91±5.0	43.8±5.20	40.1±4.20	39.85±3.95	46.2±5.20
As	186.0±6.0	139.0±13	141.1±13	270.5±13	17.5±12	130.0±13	138±18.20	198±15.20	230±15.80

Table 2 : List of elements, radionuclides, possible interference and gamma ray selected for the analysis, data from ref. 1,8.

1. Short Irradiation (2-5 minutes)

Elements	Isotope	Half-life	α -energy selected (KeV)	Decay interval	Interference
Titanium	^{51}Ti	5.79m	320.0	 20minutes	$^{30}\text{Si} (n, \alpha)$ $^{27}\text{Al} (n, p)$ $^{846}(\text{Mn}^{56})$
Magnesium	^{27}Mg	9.46m	1014,844		
Vanadium	^{52}V	3.75m	1434		
Aluminium	^{28}Al	2.32m	1779		
Sodium	^{24}Na	15.0h	1369,2754		
Dysprosium	^{165}Dy	2.32h	95		
Iodine	^{128}I	25.0m	443		
Manganese	^{56}Mn	2.58h	1810,2110,846		
Calcium	^{49}Ca	8.8m	3084		
Chlorine	^{38}Cl	37.18m	1642,2167		
Bromine	^{80}Br	17.60m	618	 12-24 hours	$^{56}\text{Fe}(n,p)$ $^{844}(^{27}\text{Mg})$
Manganese	^{56}Mn	2.58h	1810,2110,846		
Sodium	^{24}Na	15.0h	1369,2754		
Bromine	^{82}Br	35.24h	555,775		
Gallium	^{72}Ga	14.10h	834		
Antimony	^{122}Sb	2.70a	564		
Arsenic	^{76}As	26.4h	559		
Samarium	^{153}Sm	46.8h	103		
Potassium	^{42}K	12.4h	1524		

continue from table 2

11. Long Irradiation (6 hours)

Elements	Isotope	Half-life	α -ray selected	Decay interval	Interference
Europium	^{152}Eu	12.7y	122,1408		
Lutetium	^{177}Lu	6.74d	208		$^{177\text{m}}\text{Lu}(208)$
Uranium	$^{239}\text{Np}(U)$	56.3h	228,278		$^{177\text{m}}\text{Lu}(229)$
Yterbium	^{131}Yb	4.21d	283,396		
Barium	^{131}Ba	12.1d	216,496		
Neodymium	^{147}Nd	11.1d	91,531		
Lanthanum	^{140}La	40.2h	816,1597		
Cerium	^{141}Ce	32.5d	146		$^{59}\text{Fe}(143)$
Rubidium	^{86}Rb	18.7d	1078		
<hr/>					
Europium	^{152}Eu	12.7y	122,1408		
Tantalum	^{182}Ta	115d	1221		
Terbium	^{160}Tb	72.1d	980,966		
Thorium	$^{233}\text{Pa}(\text{Th})$	27.0d	312,300		$^{160}\text{Tb}(300)$
Chromium	^{51}Cr	27.8d	320		
Hafnium	^{181}Hf	42.5d	482		
Strontium	^{85}Sr	64.0d	514		29-30 days
Zirconium	^{95}Zr	65.5d	757		
Scandium	^{46}Sc	83.9d	889,1120		
Iron	^{59}Fe	45.6d	1099,1292		
Zinc	^{65}Zn	243.0d	1116		$^{46}\text{Sc}(1120)$
Cobalt	^{60}Co	5.26y	1173,1332		
Caesium	^{134}Cs	2.06y	604,796		

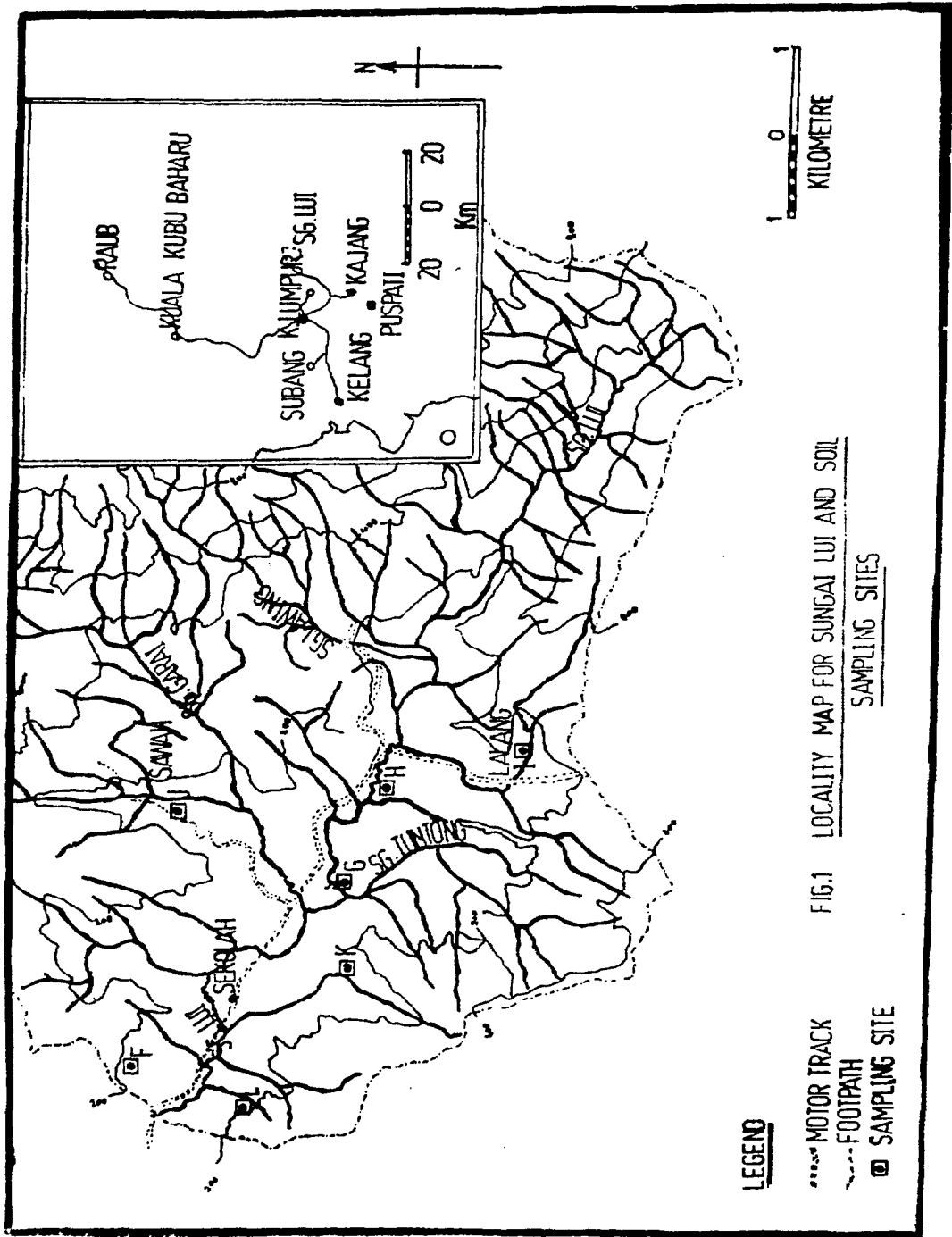
Table 3 : Interference from the (n,r) and (n, α) reaction.

Nuclear reaction	Radionuclide interfered	Contribution in mg/g isotop
^{28}Si (n,r) ^{28}Al	^{28}Al	3.292 mg
^{31}P (n, α) ^{28}Al	^{28}Al	N.D.*
^{27}Al (n,r) ^{27}Mg	^{27}Mg	279.2 mg
^{30}Si (n, α) ^{27}Mg	^{27}Mg	low (undetected)
^{24}Mg (n,r) ^{24}Na	^{24}Na	1.48 mg
^{27}Al (n, α) ^{24}Na	^{24}Na	low (undetected)
^{56}Fe (n,p) ^{56}Mn	^{56}Mn	0.157 mg

Key to table :- N.D.* , not determined.

Table 4 : Elemental contents from soils at station J, I, G, K and G, around Sungai Lui's area, Kajang, Selangor (samples were taken at 22-24 cm depths)

Elements	F	G	J	I	K
Ti	0.31±0.03	0.43±0.04	0.55±0.09	0.39±0.09	0.35±0.05
Al	11.9±0.9	6.15±0.70	7.15±0.80	9.36±0.90	19.5±0.95
Fe	2.29±0.30	2.84±0.40	2.90±0.18	2.34±0.20	3.08±0.43
Mg	1.51±0.50	0.89±0.60	0.86±0.25	1.15±0.30	0.81±0.31
Ca	-	-	-	-	-
Na	0.06±0.005	0.07±0.005	0.13±0.001	0.03±0.001	0.08±0.006
K	1.31±0.50	0.77±0.48	1.48±0.21	0.41±0.09	1.58±0.31
Mn	227±29.0	212.0±25.0	194.0±25	179.0±23.0	380.0±30.5
Sc	9.64±0.75	8.82±0.80	12.40±0.80	6.72±0.70	19.20±1.25
U	17.6±2.0	57.9±6.2	115.0±11.5	52.5±5.3	24.0±4.0
Cr	7.36±3.2	33.94±5.5	80.11±7.5	29.8±2.5	3.8±0.12
Co	1.75±0.18	1.69±0.17	1.49±0.18	2.23±0.22	4.10±1.21
Zn	47.06±10.1	38.5±8.5	61.91±20.2	49.8±8.8	38.5±10.8
Sb	1.85±0.20	1.55±0.20	1.07±0.20	0.48±0.18	1.55±0.30
Rb	255.3±50.0	85.13±20.6	106.6±28.5	48.2±12.5	598±80.5
Cs	21.4±6.8	17.60±5.8	8.79±1.8	7.47±2.5	60.5±15.3
Ba	-	126.2±25.0	157.5±21.0	-	84.8±10.0
Sr	-	-	-	-	-
La	20.9±2.1	20.14±2.0	20.1±2.0	21.2±2.0	25.0±2.5
Ce	50.2±20.1	50.70±7.8	42.0±6.8	40.12±7.5	125.0±30.8
Nd	-	-	-	-	-
Sm	4.23±0.21	3.2±0.18	4.23±0.91	3.16±0.85	4.95±2.5
Eu	0.65±0.08	0.75±0.09	0.56±0.04	0.54±0.05	0.58±0.21
Tb	-	-	-	-	0.19±0.05
Dy	3.44±0.95	2.44±0.50	3.44±0.48	2.54±0.50	3.45±0.61
Yb	5.76±2.1	2.81±2.1	5.76±1.50	2.19±0.75	8.91±3.5
Lu	0.45±0.15	0.39±0.15	0.37±0.09	0.30±0.09±	0.98±0.09
Zr	390.0±30.0	389.0±25.0	278.7±25.0	328.1±30.0	427.0±28.0
Hf	10.01±4.0	9.83±3.7	6.47±1.25	7.02±2.8	9.46±2.1
Ta	-	-	1.65±0.20	-	-
U	13.5±1.8	3.76±0.98	-	10.0±1.0	16.8±2.1
Th	51.90±7.8	27.06±5.8	10.80±0.85	45.5±7.8	53.8±9.1
Cl	57.5±13.0	70.2±15.0	80.0±40.1	78.0±30.0	80.9±20.1
Br	19.07±2.5	25.19±1.8	6.32±1.20	26.12±2.0	15.8±6.2
I	40.0±10.5	-	-	-	28.8±7.1
As	91.9±5.8	63.04±6.8	6.45±0.61	18.07±2.1	180.0±20.0
Ga	39.5±3.8	14.90±0.15	6.21±0.06	25.8±0.18	24.8±4.1

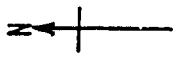


LEGEND

- MOTOR TRACK
- FOOTPATH
- SAMPLING SITE

FIG.1 LOCALITY MAP FOR SUNGAI LUIT AND SOIL SAMPLING SITES

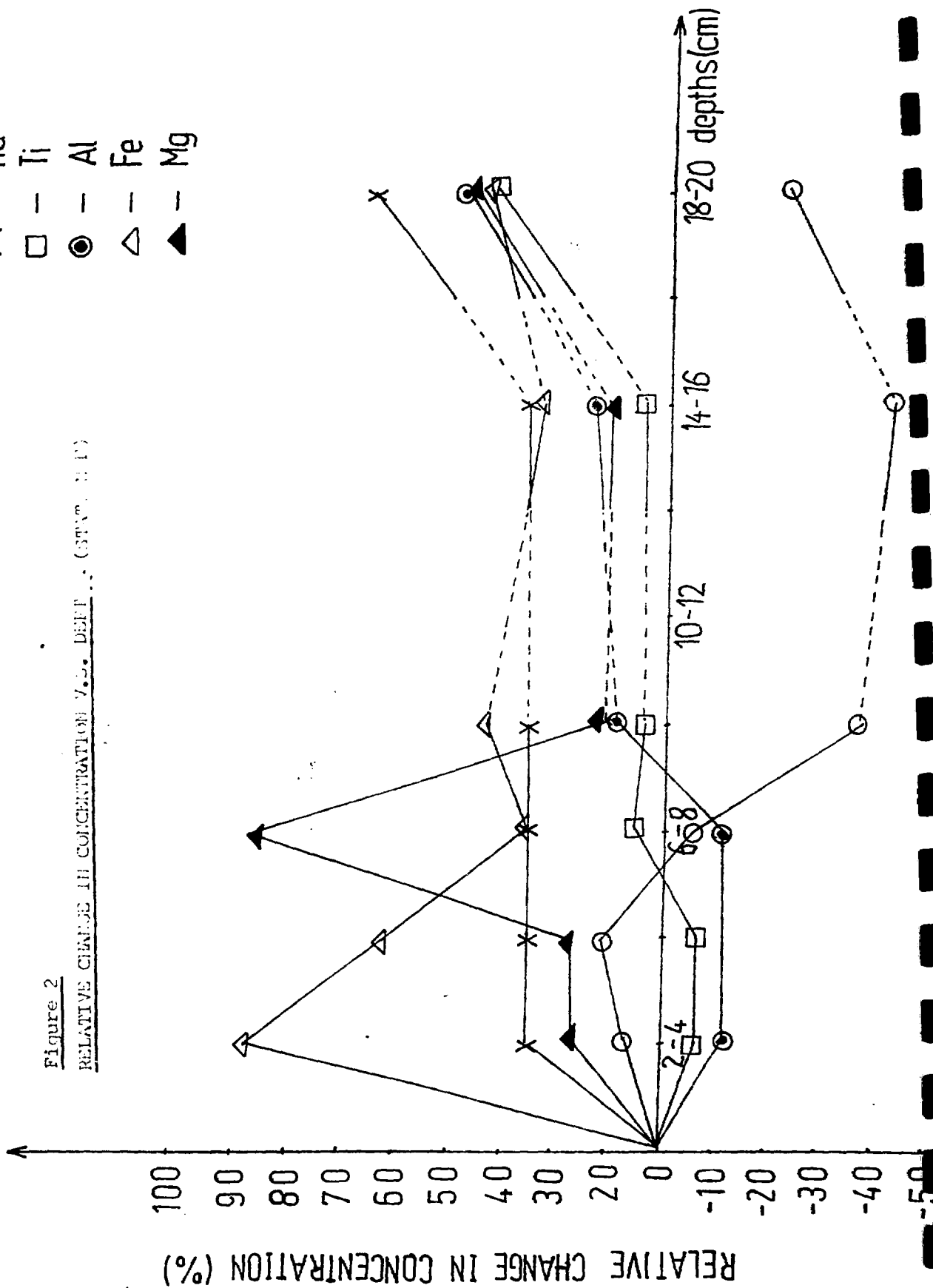
1 0 KILOMETRE



20 0 20 Km

- — K
- × — Na
- — Ti
- — Al
- △ — Fe
- ▲ — Mg

Figure 2
RELATIVE CHANGE IN CONCENTRATION V.S. DEPTH (STATION 111)



- - K
- ⊙ - Al
- × - Na
- △ - Fe
- - Ti
- ▲ - Mg

Figure 3
RELATIVE CHANGE IN CONCENTRATION V.S. DEPTH (cm)

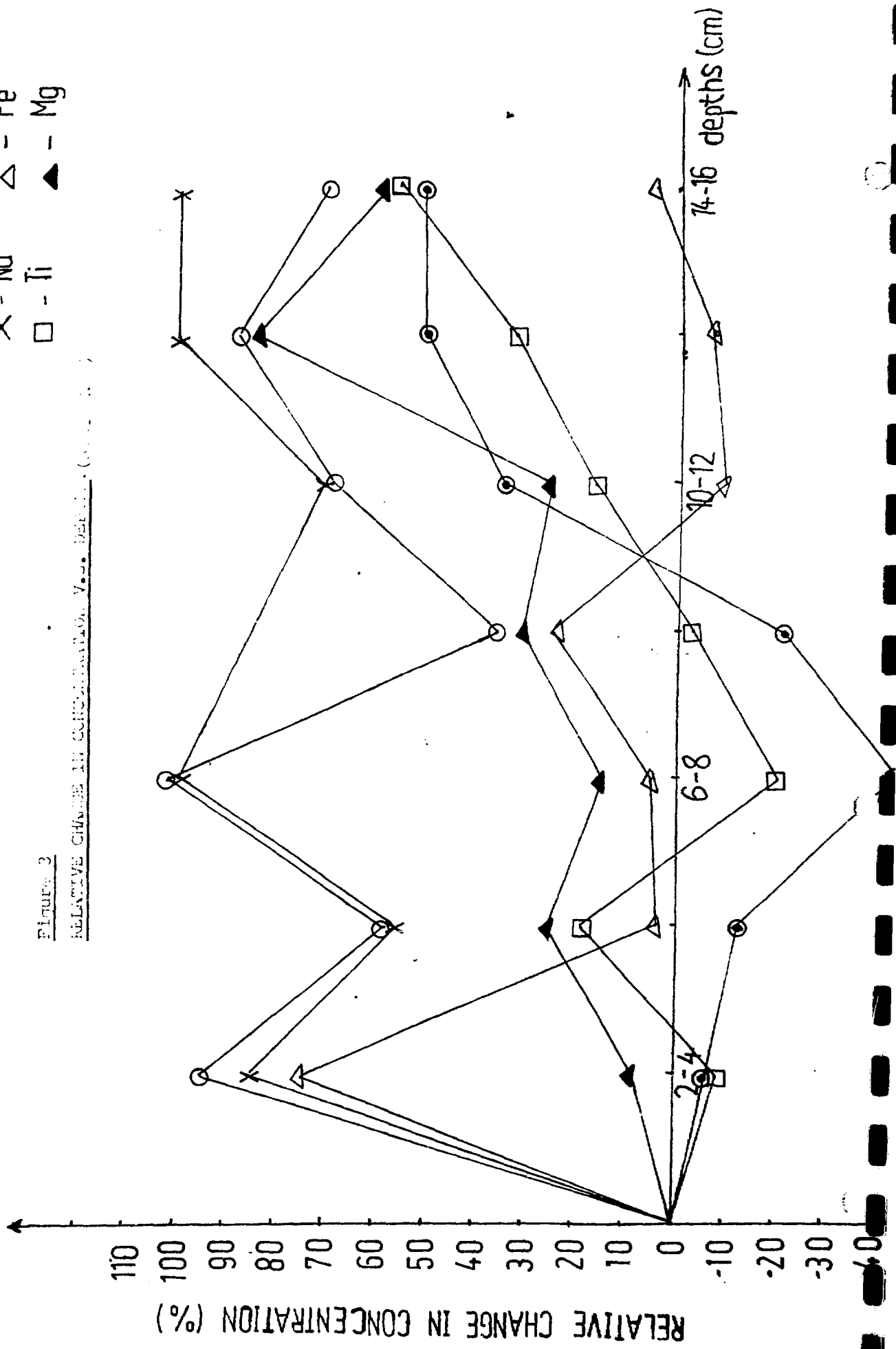


Figure 4

RELATIVE CHANGE IN CONCENTRATION V.S. DEPTH (STATION K)

