AN INAA STUDY ON SOIL BACKGROUND VALUES OF U, Th AND REE IN CHINA

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ABSTRACT

The background values of elements in soil have been investigated by INAA. The contents of 8 REE (La, Ce, Nd, Sm, Eu, Tb, Yb and Lu), U and Th in 364 top soil samples (A horizon) in China were determined by INAA. The samples were collected from some typical areas in China and covered main soil types of these areas. The background values of above elements in soil of the different areas and the whole soil studied in China are reported in present paper. The distribution characteristics of REE, U and Th in soils are also discussed.

Keywords: INAA REE U Th Soil

1 INTRODUCTION

Soil is one of the essential factors of the ecological environmental system which includes air, water, soil, organisms, *etc.* and serves as an important medium for the accumulation, transformation and migration of various nutrient and toxic substances in the system. Therefore, the study on natural background contents of trace elements in soil is of vital importance in environmental and biological sciences and pedogeochemistry. It can provide the most basic data for assessment of environmental quality, for evaluation of pollution and for scientific farming with trace element fertilizers.[1,2]

During the last decade, the investigation of background values of trace elements in soils has been widely carried out in China by instrumental neutron activation analysis (INAA). A total of 364 soil samples were collected from the areas of the Guangzhou and Hainan (G.H.), the Xiangjiang Valley of Hunan Province (X.V.), the Songliao Plain area (S.P.), Tianjin (T.J.), North Xinjiang (N.X.) and the Mt. Qomolangma region (Mt.Q.).[3-10]

The sampling sites were free from possible pollutant sources. The samples were taken from different natural genetic horizons in the profiles respectively. Twenty-six elements in the soil samples were determined by INAA. In this paper the background values of La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, U and Th in top soils are reported. The distribution characteristics of the elements in the soils derived from different parent materials were also discussed. The results of the other elements will be reported in separate papers.

2 EXPERIMENTAL

2.1 Preparation of samples and standards

The soils were air-dried and ground with an agate mortar and sieved with a 100 mesh nylon sieve. Fifty mg of each soil sample was accurately weighed and wrapped with a high purity aluminium foil for irradiation. Standards were prepared by mixing the elements of interest, with sufficient considerations on the nuclear characteristics and chemical behaviours of elements and possible counting interference. The standard solutions were pipetted onto filters, air-dried and also wrapped with the Al foils for irradiation.

2.2 Irradiation and counting

The irradiations were performed in the reactors at the Institute of Atomic Energy or the Qinghua University, Beijing, with integral neutron fluxes of $5\times 10^{17}-1\times 10^{18}$ n/cm^2. The induced radioactivities were measured by a SCORPIO-3000 gamma ray spectrometer with large volume Ge(Li) or HPGe detectors coupled to a microcomputer.

Interferences in the gamma spectrometry were avoided by choosing suitable cooling periods (5, 15 or 30 d) and the interference-free gamma peaks. Contributions of overlapping peaks from interfering nuclides and the fission products of U, such as ^{140}La, ^{141}Ce and ^{147}Nd were evaluated from suitable standards and corrected automatically by the data processing codes. The radionuclides and their nuclear data for this study are listed in Table 1.

Table 1

Nuclear data of investigated elements

Element	Radionuclide	Half-life	*E* (keV)	Main interference
La	^{140}La	40.2 h	1596.1	U (n,f)
Ce	^{141}Ce	32.5 d	145.4	^{175}Yb (144.9), U (n,f)
Nd	^{147}Nd	11.1 d	530.9	U (n,f)
Sm	^{153}Sm	47.0 h	103.2	^{233}Pa (103.0), ^{153}Gd (103.2)
Eu	^{152}Eu	12.0 y	1408.0	
Tb	^{160}Tb	72.1 d	879.4	
Yb	^{169}Yb	32.0 d	177.2, 198.0	^{160}Tb (197.1), ^{182}Ta (198.4)
Lu	^{177}Lu	6.72 d	208.4	^{239}Np (209.8)
U	^{239}Np	2.38 d	228.2, 277.5	
Th	^{233}Pa	27.0 d	311.9	

3 RESULTS AND DISCUSSION

The contents of the ten elements in top soil samples were determined by INAA.

Different types of major soils and soils derived from different parent materials are represented by the samples.

Statistical analyses have been made on the results. The average contents of elements were chosen on the basis of the frequency distribution. The arithmetic mean was taken for the normal distribution, the geometric mean for the lognormal, and the median for the skewness. In this work, the average contents of the elements in top soil were taken as the background value of the soil.

3.1 The contents and distribution of REE in soil

The concentrational averages and ranges of the 8 REE in 364 soil samples from different areas in China are listed in Table 2. The REE concentrations of the whole samples are compared with the world averages reported in Ref.[12]. The total REE content covered all 14 REE, or those were not determined could be estimated from the REE pattern normalized by chondrite.

Table 2

The background values of REE in soils of China ppm

Element	G.H. n = 18	X.V. n = 96	S.P. n = 96	T.J. n = 36	N.X. n = 104	Mt.Q. n = 14	Whole soils (364)	World' soil[12]
La	44.2*	39.7	34.4	35.1	30.0	30.5	34.9	40
	8.67-132* *	8.00-184	12.4-53.0	27.4-45.5	7.23-46.5	7.11-50.6	7.11-184	2-180
Ce	99.7	92.5	70.7	74.1	57.6	67.2	74.3	50
	15.1-264	16.0-454	24.1-111	56.5-92.5	19.2-96.0	16.5-110	15.1-454	3-170
Nd	53.0	30.3	35.1	32.5	28.6	31.7	32.5	35
	17.5-162	13.0-159	14.3-62.7	24.5-43.8	7.50-46.4	9.30-64.9	7.50-162	4-63
Sm	6.53	5.95	5.90	6.21	5.79	5.39	5.92	4.5
	1.09-18.8	1.60-25.8	1.96-8.30	4.66-7.40	2.05-8.84	1.73-9.65	1.09-25.8	0.6-23
Eu	1.26	1.11	1.17	1.28	1.18	0.78	1.16	1
	0.18-2.96	0.34-6.99	0.47-1.85	1.10-1.64	0.48-1.59	0.24-1.33	0.18-6.99	0.1-3.2
Tb	0.89	0.81	0.77	0.79	0.81	0.66	0.80	0.7
	0.16-2.03	0.32-2.68	0.31-1.23	0.61-1.06	0.39-1.34	0.20-1.37	0.16-2.68	0.1-1.6
Yb	3.42	2.80	2.52	2.34	2.76	2.09	2.67	3.0
	1.08-8.50	1.00-7.50	0.73-3.45	1.93-2.97	0.81-5.52	0.37-4.59	0.73-8.50	0.04-12
Lu	0.42	0.47	0.42	0.47	0.43	0.37	0.44	0.4
	0.11-1.09	0.19-1.17	0.15-0.57	0.38-0.59	0.19-0.76	0.11-0.78	0.11-1.17	0.1-0.7
Total* * *	240	197	172	177	150	160	177	156

* Average * * Range * * * Total contents of 14 REE including estimated values of the non-analyzed REE

The results show that the total REE contents in soils from the typical areas in China rank as follows: Guangzhou and Hainan > The Xiangjiang valley > Tianjin > The Songliao plain > Mt. Qomolangma region > North Xinjiang. The average content of total REE in the whole soils is 177 ppm, which is close to those in the world's soil (156 ppm).

In order to facilitate the comparison of REE abundances among the sampling areas, the contents of REE in each sample are normalized to chondritic abundances[11] and the REE pattern was plotted. The REE patterns of soils obtained in different

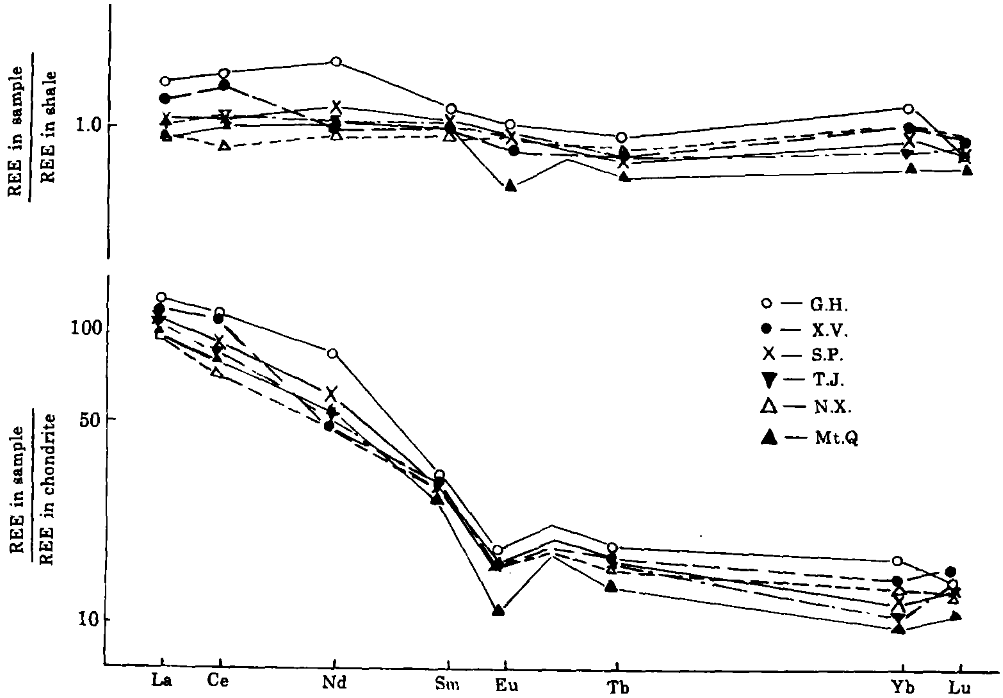

Fig.1 REE Patterns of soils from some typical areas in China

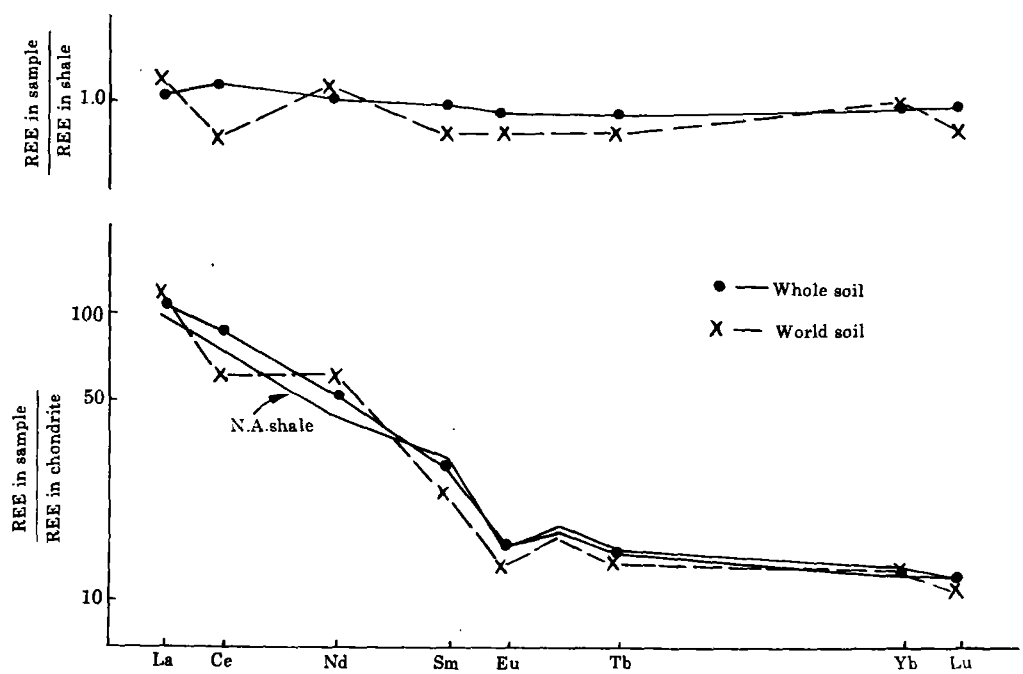

Fig.2 Comparison of REE patterns in the whole soil from China with the world' soil and NASC

areas are shown in Fig.1. All samples from these areas share a very similar REE pattern, with the light REE steeply sloped, the heavy REE flat, and a negative Eu anomaly.

Table 3

The background values of U and Th in soils of China ppm

Area	n	U		Th		Th/U
		Average	Range	Average	Range	
Guangzhou	10	7.38	2.33-13.9	55.1	13.2-167	7.47
Hainan	8	4.20	2.10-7.12	14.4	6.76-26.9	3.43
X.V.	96	4.20	1.50-14.1	17.0	7.00-83.0	4.05
S.P	96	2.34	0.47-4.27	10.8	3.15-15.7	4.62
Tianjin	36	1.77	0.74-2.47	12.1	8.57-15.0	6.84
N.X.	104	2.71	0.94-9.46	10.0	2.75-17.1	3.69
Mt.Q.	14	4.88	0.91-13.2	15.7	4.60-27.9	3.22
World'soil[12]	-	2.0	-	9.0	-	4.5
Crust*	-	2.7	-	9.6	-	3.56

* Taylor (1964)

In comparison with the North American Shale Composite (NASC),[13] which is generally considered as the representative of the continental component, the light REE in the soils of Guangzhou and Hainan, and the Xiangjiang valley are obviously enriched, but they are deficient in the North Xinjiang and the Mt. Qomolangma region.

The REE pattern of the whole soil is also compared with those of NASC and the world's soil in Fig.2. It is shown that the REE pattern of the whole soil is nearly identical with those of NASC and the world's soil, but the contents of light REE in the whole soil are slightly higher than those in NASC and the world's soil.

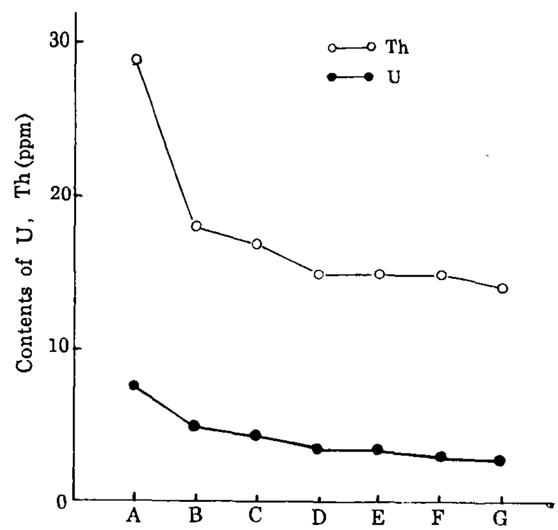

Fig.3 Distribution of U, Th in the soils derived from different parent materials for the red earth

A-Granite B-Limestone C-Quarternary red clay D-Sandstone E-Purple sandy shale F-Slate shale G-Basalt

Similar results could be observed, too, from the REE patterns normalized by NASC. They are shown at the tops of Fig.1 and 2.

3.2 The contents and distributions of U and Th in soil

The U and Th contents in the soil samples are listed in Table 3. It can be seen that the background values of U and Th in the Chinese soils are generally higher than that in the world's soil and in the crust. In Guangzhou and Hainan, the Xiangjiang valley and the Mt. Qomolangma region U and Th contents are much higher, and these places are considered as high background areas in China.

Fig.3 shows the distribution of U and Th in different parent materials of soil of the red earth collected from the Xiangjiang valley. The results show that the contents of U and Th in these parent materials rank as follows: Granite > Limestone > Quartenary red clay > Sandstone > Purple sandy shale > Slate shale > Basalt.[8]

It is clear that the contents of U and Th for granite are the highest among different parent materials and are the lowest for slate shale and basalt. Although the contents of elements in soil are affected by the weathering and various soil forming conditions, they are mainly controlled by its parent material.

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