

THE BACKGROUND VALUES OF RARE-EARTH AND RADIOACTIVE ELEMENTS IN WATER SYSTEM OF SOURCE AREA OF THE CHANGJIANG RIVER

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ABSTRACT: Using neutron activation analysis method we determined contents of rare-earth and radioactive elements (La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Cs, Rb, Sb, Sc, Sr, Ba, U, Th) in source water system of the Changjiang (Yangtze) River, which is mainly composed of the Tuotuo River, the Chumaer River, and the Buqu River. The contents of these elements in the unfiltered water have a great variation and a close correlation with the water turbidity. The contents of these elements in filtered water only have a little variation and are lower than those in the unfiltered water. The variations in contents of these elements in sediments are also very little. These elements in the unfiltered water are in geometric distribution, except Sc. Most of the elements in sediments are in arithmetic distribution, but Cs, Sb, Th, are in deviation distribution. The contents of most of these elements in the river source area correspond to the contents of fresh water of the earth. Most of these elements have a little variation in their contents in sediments. The variation coefficients of most of these elements are less than 30%. There are remarkable correlations between the contents of rare elements in sediments.

KEY WORDS: source area of the Changjiang River, background value, rare-earth radioactive elements, neutron activation analysis method

I. INTRODUCTION

The water system of the source area of the Changjiang River is mainly composed of the Tuotuo River, the Chumaer River and the Buqu River. The drainage area is 14 thousand square kilometer, the altitude is 4,200–4,700 m, the average annual temperature is be-

low 3 °C , even the highest monthly temperature is not up to 5°C , the annual precipitation is 200–350 mm. Because of dry and cold weather, the physical weathering is the main process of weathering, chemical weathering is very weak, the trace elements in rivers transport mainly with suspended particulate, the contents of trace elements in the filtered water is very low, compared to the contents in the unfiltered. The contents of trace elements in the filtered water can pass through 0.45 um membrane. The analysis of weathering products indicates that the trace elements in rivers of this area are still in the beginning period of the formation.

II. METHODS AND CONCLUSIONS

Using neutron activation analysis method we determined the natural contents of rare -earth and radioactive elements (La, Ce, Nd, Sm, Eu, Tb, Lu, Cs, Rb, Sb, Sc, Sr, Ba, U, Th) in the source water system of the Changjiang River (Fig.1).

Table 1 lists the contents of these elements in major rivers of source area of the Changjiang River. It is found that the contents in the unfiltered water have a great variation and a close correlation with the turbidity of water. This demonstrates that the contents of these elements are mainly influenced by the contents of suspended substances in the river water. The contents of these elements in the filtered water only have a little variation and are lower than those in the unfiltered water, the variation and are of these elements in sediments are also very little.

The background values of rare -earth and radioactive elements in rivers of source area of the Changjiang River are listed in Table 2. We can find in this table all these elements in the unfiltered water are in geometric distribution, except Sc, these elements are in arithmetic or geometric distribution, most of these elements in sediment are in arithmetic distribution but Cs, Sb, Th are in derivation distribution.

Table 3 listed the contents of some rare -earth and radioactive elements in freshwater.

1. The contents of most of these elements in source area of the Changjiang River correspond to the contents of fresh water of the earth. La, Ce, Nd, Ba, and Lu have higher contents in source area of the Changjiang River than the in average contents in freshwater of the earth. The content ranges of Nd and Sr are higher than those in freshwater of the earth. The contents of La, Ce, Nd, Sm, Eu, Yb, Lu in the Beilu River and the Achi River are about ten times higher than their average contents in the whole drainage system.

2. The contents of Sr and Ca in the filtered water have a remarkable correlation because their similar chemical properties, the coefficient equals 0.90. But Sr is easier to be absorbed by suspended particulate than Ca. $Sr/ Ca = 41.4$ this value is lower than that in meteoric stone.

3. From the distribution patterns and ranges of the contents of these elements in sediments, we can find that most of these elements have a little variation in their contents in

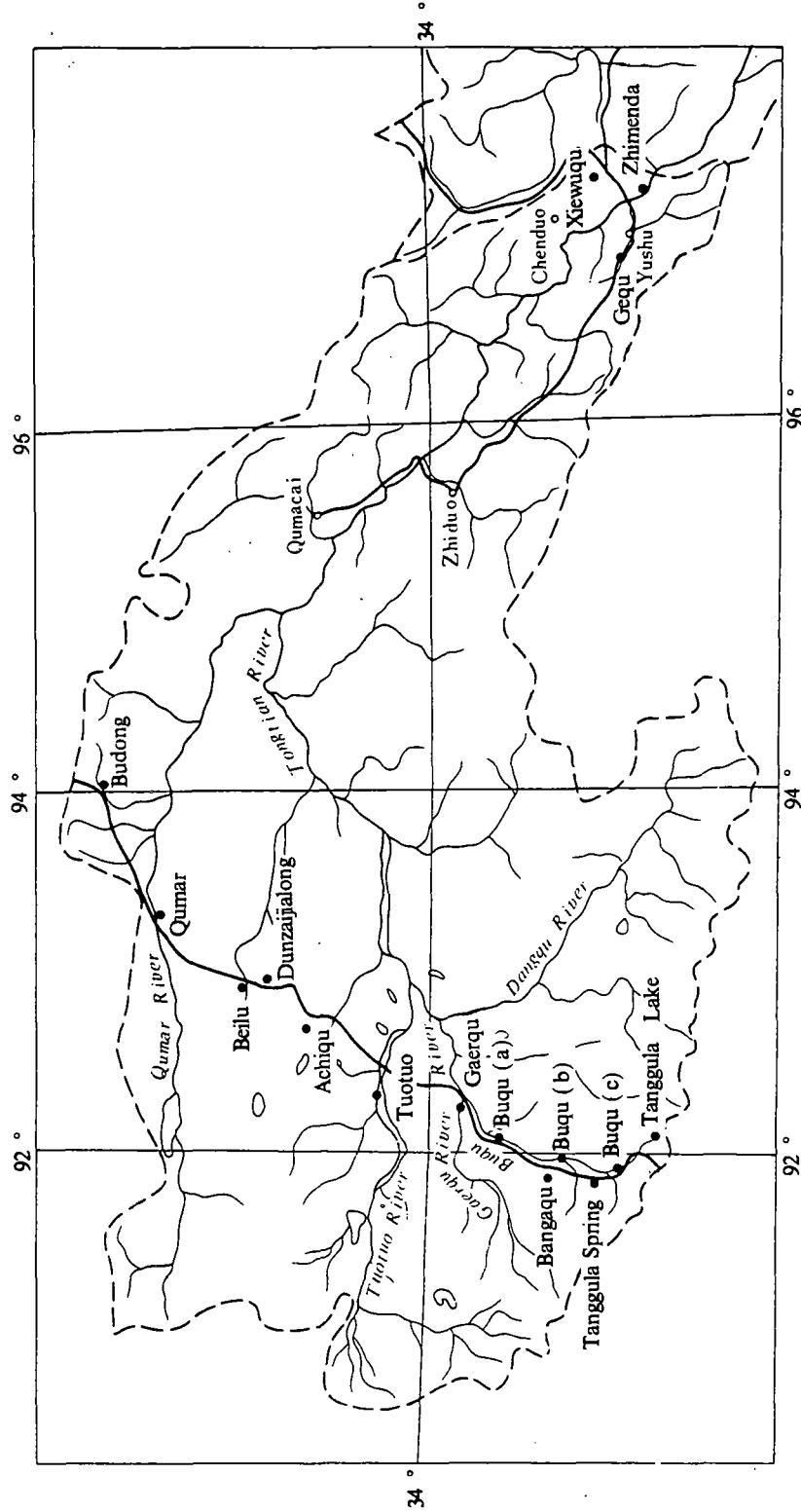


Fig.1 Sampling sites in the source area of the Changjiang River

Table 1 Contents of rare-earth and radioactive elements in rivers of source area of the Changjiang River

Rivers	Specimen	Rb	Cs	Sr	Ba	Sb	Sc	U	Th	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu	Unit: ug/ l(water);mg/ kg(sediment)
Chumaer River	A	2.9	0.26	2000	63	0.18	0.2	1.7	0.2	0.8	1.4	0.7	0.10	0.02	0.03	0.01	0.00	
	B	1.3	0.03	2120	60	0.12	0.001	1.7	0.01	0.13								
	C	25.0	1.4	110	330	0.50	1.5	6.7	2.2	9.0	15.0	7.0	1.4	0.26	0.29	0.5	0.10	
	D	78.0	6.2	250	430	1.50	9.3	3.7	13.1	49.0	83.0	44.0	7.8	1.29	0.99	3.2	0.52	
Budong spring	A	11.3	1.19	710	87	0.43	1.3	1.5	0.8	2.0	3.8	1.36	0.33	0.07	0.03	0.25	0.034	
	B	0.4	0.02	660	42	0.19	0.002	1.3	0.0	0.012	0.38						0.004	
	C	75.0	5.0	240	400	1.70	9.5	2.0	9.3	39.0	69.0	49.0	5.8	1.79	0.88	3.0	0.41	
	D	74.0	5.0	320	340	1.70	9.2	3.5	11.2	46.0	82.0	46.0	7.6	2.11	1.10	4.6	0.64	
Gequ River	A	0.9	0.06	500	37	0.09	0.064	1.2	0.02	0.1	0.27	0.10	0.02	0.002	0.01	0.01	0.004	
	B	0.6	0.05	470	34	0.08	0.052	1.2	0.008	0.012	0.25	0.38					0.002	
	C	85.0	5.7	170	380	1.30	8.0	2.1	8.6	29.0	47.0	37.0	4.6	1.57	0.82	3.7	0.44	
	D	105.0	7.0	130	410	1.20	8.0	2.7	10.3	37.0	63.0	34.0	5.7	1.73	0.90	4.1	0.48	
Tongtian River	A	49.0	10.5	1550	177	0.07	3.5	2.3	3.5	9.7	16.7	7.3	1.47	0.29	0.17	0.57	0.084	
	B	6.9	1.0	1330	65	0.07	0.001	1.5	0.013	34.0							0.004	
	C	55.0	4.1	240	340	1.00	6.0	1.7	5.6	22.0	34.0	16.0	3.3	0.99	0.26	2.5	0.29	
	D	64.0	5.5	100	380	1.30	7.4	3.4	10.7	45.0	78.0	48.0	7.2	1.86	0.92	3.9	0.55	

Note: A: unfiltered water; B: filtered water; C: sediment; D: fine sediment

(to be continued)

Rivers	Specimen	Rb	Cs	S ₁	Ba	Sb	S _c	U	Th	L _a	C _e	Nd	S _m	Eu	T _b	Y _b	Lu	
Tuotuo River	A	111.0	44.0	2340	211	0.07	3.2	3.0	3.7	8.5	14.5	7.8	1.3	0.24	0.14	0.39	0.09	
	B	59.0	25.0	2220	82	0.07	0.004	2.0	0.1			2.8						
	C	75.0	5.0	690	630	1.30	3.6	1.8	9.3	21.0	31.0	15.0	2.9	0.71	0.40	0.90	0.13	
	D	88.0	5.0	620	310	2.80	7.6	1.3	11.2	16.0	53.0	27.0	2.3	1.03	0.79	1.7	0.31	
Beilu River	A	160.0	19.6	4600	560	1.91	14.5	5.5	13.1	38.9	65.0	32.3	5.9	1.05	0.88	2.2	0.39	
	B	6.4	0.5	4000	110	0.26	0.025	2.1	0.03	0.16								0.006
	C	71.0	5.0	170	430	0.70	4.5	1.9	8.6	24.0	39.0	18.0	3.9	0.69	0.62	1.7	0.27	
	D	87.0	5.0	310	450	1.10	7.8	3.3	10.3	48.0	84.0	42.0	7.3	1.24	1.14	2.8	0.45	
Jialong River	A	13.0	1.1	1460	172	0.40	0.7	1.2	0.6	2.8	5.1	2.3	0.5	0.11	0.07	0.15	0.025	
	B	0.8	0.02	1100	103	0.08	0.001	1.0			0.1	0.5	0.0	0.003				
	C	51.0	6.0	230	390	0.80	5.4	1.7	5.6	22.0	35.0	23.0	4.0	0.76	0.58	1.4	0.22	
	D	66.0	6.3	190	350	0.90	7.0	2.0	10.7	22.0	35.0	25.0	3.9	0.81	0.62	1.6	0.25	
Achiqiu River	A	184.0	18.4	5300	700	2.40	15.8	4.9	15.1	40.5	76.0	40.3	5.5	1.18	1.00	2.5	0.42	
	B	9.1	0.44	4340	110	0.16	0.003	2.1		0.12	0.2			0.004			0.009	
	C	127.0	9.0	300	630	0.50	3.2	1.0	11.4	14.0	26.0	13.0	2.4	0.53	0.38	0.8	0.14	
	D	90.0	6.3	450	480	0.90	7.9	2.6	10.8	30.0	47.0	30.0	5.0	0.85	0.74	1.7	0.29	

(to be continued)

Rivers	Specimen	Rb	Cs	Sr	Ba	Sb	Sc	U	Th	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu
Gaerqu River	A	166.0	33.3	780	480	4.92	8.9	4.2	12.8	25.2	44.0	20.0	3.6	0.73	0.48	1.4	0.23
	B	6.9	1.2	530	49	0.47	0.005	1.5	0.02	0.2	0.01	0.003					0.006
	C	125.0	6.7	460	670	2.70	4.1	2.0	8.3	25.0	38.0	20.0	3.2	0.72	0.40	1.0	0.17
	D	115.0	8.3	430	700	4.40	6.1	3.0	10.8	94.01	47.0	84.0	7.8	1.57	1.40	4.9	0.89
Buqu River	A	114.0	25.9	760	360	3.86	8.5	2.3	9.1	23.6	43.0	25.6	4.0	0.74	0.62	1.6	0.25
	B	2.7	0.9	510	42	0.58	0.002	0.5	0.02					0.004			0.003
	C	88.0	11.2	180	330	4.20	6.4	1.8	7.1	24.0	42.0	21.0	3.6	0.79	0.55	1.5	0.23
	D	98.0	14.9	220	840	4.70	9.8	4.3	15.6	55.0	94.0	41.0	9.4	1.36	1.37	3.6	0.56
Bangqua River	A	17.7	2.8	1100	97	1.10	1.5	0.7	1.5	4.6	8.0	4.7	0.77	0.14	0.11	0.28	0.05
	B	1.0	0.4	1000	32	0.39	0.001	0.4		0.007				0.002			0.003
	C	87.0	13.3	180	300	4.10	5.8	2.1	7.5	29.0	43.0	19.0	4.5	0.78	0.68	1.8	0.27
	D	89.0	17.2	260	410	4.70	8.3	3.1	11.3	41.0	66.0	33.0	5.8	1.08	0.93	2.5	0.39
Buqu River	A	56.4	14.6	550	152	1.95	3.6	1.1	4.2	10.5	19.3	10.5	1.77	0.31	0.22	0.69	0.11
	B	4.4	1.5	450	42	0.43	0.003	0.5	0.02								0.005
	C	93.0	14.9	180	340	4.90	6.6	2.0	8.9	29.0	47.0	19.0	4.4	0.88	0.64	1.7	0.22
	D	96.0	18.2	300	410	5.10	8.7	3.7	15.4	47.0	80.0	46.0	7.0	1.19	1.04	2.8	0.43

Table 2 Background values of rare earth and radioactive elements in source area of the Changjiang River

Elements	Specimen	N	DP	AM	SD	NAM	NS	Unit: ug/l (water); mg/kg (sediment)			
								10%	50%	90%	BV
La	A	13	G	13.2	14.2	5.6	5.7	0.3	8.5	34.8	5.6
	B	3	A	0.13	0.03	0.12	1.3	0.03	0.12	0.15	0.13
	D	12	A	44	20	40	1.6	17	46	54	44
Ge	A	13	G	23	25	11	5.0	0.6	15	59	5.0
	B	6	G	0.16	0.06	0.15	1.48	0.06	0.17	0.22	0.15
	D	12	A	76	28	72	1.4	37	79	92	76
Nd	A	13	G	12	13	5.1	5.5	0.3	7.3	30.2	5.1
	B	3	A	0.39	0.09	0.44				0.39	0.3-0.5
	D	12	G	42	16	40	1.4	25	42	48	40
Sm	A	13	G	2.0	2.0	0.93	5.2	0.04	1.3	5.1	0.93
	B										
	D	12	A	6.4	2.0	6.0	1.5	2.6	7.1	7.8	6.4
Eu	A	13	G	0.38	0.40	0.17	5.87	0.007	0.24	0.96	0.17
	B	5	G	0.003	0.008	0.003	1.3	0.001	0.003	0.004	0.003
	D	12	A	1.3	0.4	1.3	1.3	0.8	1.3	1.8	1.3

(to be continued)

Elements	Specimen	N	DP	AM	SD	NAM	NS	10%	50%	90%	BV	RBV
Tb	A	13	G	0.30	0.34	0.14	4.2	0.01	0.14	0.80	0.14	0.02-0.91
	D	12	A	1.0	0.24	1.0	1.3	0.6	1.0	1.3	1.0	0.7-1.3
Yb	A	13	G	0.8	0.84	0.37	5.0	0.02	0.39	2.02	0.37	0.05-2.9
	D	12	A	3.1	1.3	2.9	1.5	1.6	3.0	4.5	3.1	1.7-4.6
Lu	A	13	G	0.13	0.14	0.067	4.20	0.005	0.08	0.35	0.067	0.01-0.42
	B	9	G	0.005	0.002	0.004	1.6	0.002	0.004	0.006	0.004	0.002-0.008
U	D	12	A	0.48	0.19	0.45	1.4	0.26	0.47	0.42	0.48	0.25-0.79
	A	13	G	2.4	1.6	1.9	1.9	0.8	1.7	4.7	1.9	0.8-4.5
Th	B	13	A	1.3	0.63	1.1	1.8	0.4	1.3	2.1	1.3	0.4-2.1
	D	12	D	4.9	6.4	3.5	2.0	1.4	3.4	4.2	3.4	1.4-1.2
Rb	A	13	G	5.2	5.4	2.0	6.7	0.07	3.5	13.0	2.0	0.2-23.5
	B	4	A	0.014	0.001				0.012		0.014	0.001-0.029
D	D	12	D	12	1.9	12	1.2	10	11	15	11	10-15
	A	13	G	70	68	31	5.2	2	49	162	31	4-262
D	B	13	G	7.7	15.6	2.6	4.4	0.4	2.7	8.4	2.6	0.4-17.2
	D	12	A	88	15	15	86	1.2	64	89	91	88

(to be continued)

Elements	Specimen	N	DP	AM	SD	NAM	NS	10%	50%	90%	BV	RBV
Cs	A	13	G	13	14	4.6	7.6	0.1	10.5	31.1	4.6	0.3-62.6
	B	13	G	2.3	6.7	0.30	8.0	0.02	0.44	1.39	0.30	0.02-4.35
	D	12	D	8.8	5.0	7.8	1.6	5.0	6.3	17.0	6.3	5.0-17.0
Sr	A	13	G	1685	1578	1176	2.4	325	1100	3922	1176	377-3667
	B	13	G	1457	1357	993	2.5	275	1000	3466	993	300-3260
	D	12	A	298	146	266	1.7	106	280	446	298	110-486
Ba	A	13	G	244	213	171	2.5	45	172	536	171	53-546
	B	13	G	62	30	56	1.6	31	49	108	56	30-102
	D	12	G	459	156	440	1.3	319	410	656	440	303-639
Sb	A	13	G	1.4	1.6	0.60	4.55	0.07	0.46	3.42	0.60	0.08-4.20
	B	13	G	0.23	0.18	0.18	2.20	0.07	0.16	0.46	0.18	0.07-0.48
	D	12	D	2.5	1.7	2.0	2.0	0.9	1.6	4.7	1.6	0.9-4.7
Sc	A	13	G	4.9	5.4	2.1	5.2	0.1	3.2	12.9	2.1	0.3-17.2
	B	13	D	0.008	0.015	0.003	3.44	0.001	0.002	0.019	0.002	0.001-0.019
	D	12	A	8	1.1	8	1.1	6.3	8.0	9.3	8.0	6.7-9.4

Table 3 Comparison of background values of rare-earth and radioactive elements
in filtered water in different areas

Elements	Source area of the Changjiang River	Upstream of the Changjiang River and Pudu drainage area		Average concentrations in freshwater of the earth	Range of concentrations in freshwater of the earth
		Dongting lake drainage area	Upstream of the Changjiang River and Pudu drainage area		
La	0.13	0.05	0.04	0.1	0.05-0.80
Ce	0.15	0.13	0.05	0.2	0.1-0.2
Nd	0.39	0.4	0.06	0.2	0.06-0.25
Sm	0.005	0.01	0.06	0.06	0.01-0.12
Eu	0.003	0.005	0.006	0.006	0.002-0.009
Tb		0.004	0.003	0.003	0.001-0.005
Yb	0.030	0.007	0.011	0.01	0.005-0.20
Lu	0.005	0.003	0.003	0.003	0.002-0.005
U	1.25	0.30	0.40	0.40	0.02-5.00
Th	0.014	0.007	0.004	0.03	0.007-0.20
Rb	2.5	2.3	1.1	1.0	0.6-9.0
Cs	0.30	0.06	0.015	0.02	0.005-1.00
Sr	990	60	220	70	3-100
Ba	55	28	29	10	3-150
Sb	0.18	0.3	0.19	0.20	0.01-5
Sc	0.003	0.005	0.006	0.01	0.004-0.04

sediments. The variation coefficients of most of these elements are less than 30%. But the contents of Ce, Nd, Sm, Tb, Yb, and Lu in Gaerqu are 50–100% higher than the average contents of them in the whole drainage area.

4. There are remarkable correlations between the contents of rare elements in sediments in this area. The correlation coefficients of these elements are listed in Table 4. The coefficients of La, with heavy rare elements Ce, Nd, Sm are 0.76, 0.92, those of radiant elements U with Th, Sc with Th are 0.61, 0.67 respectively. This indicates that these elements have similar chemical properties, chemical behavior and regulation of transportation and transformation.

Table 4 The correlation coefficients of rare -earth
and radioactive elements in sediments

Elements	r	a	b	n
La -Ce	0.97	13.8	1.4	12
La -Nd	0.95	8.31	0.76	12
La -Sm	0.75	3.09	0.075	12
La -Yb	0.76	1.18	0.043	12
La -Lu	0.92	0.12	0.008	12
Yb -Lu	0.92	0.037	0.14	12
U -Th	0.61	7.7	1.38	12
Sc -Th	0.67	2.0	1.20	12

5. The distribution patterns of rare elements in sediments in the source area of the Changjiang River.

Fig.2 shows the distribution patterns of rare elements in sediments. The distribution patterns show agreeable in different drainage systems. The curve of light rare elements La -Eu is very steep, and the curve of heavy rare elements Eu -Lu is even. Besides, we can find from Fig.2 that the average contents of rare elements in the source area of the Changjiang River are close to the contents in Dodging Lake drainage system and in freshwater of the earth, but lower than those in the upstream of the Changjiang River and the Pudu River drainage system.

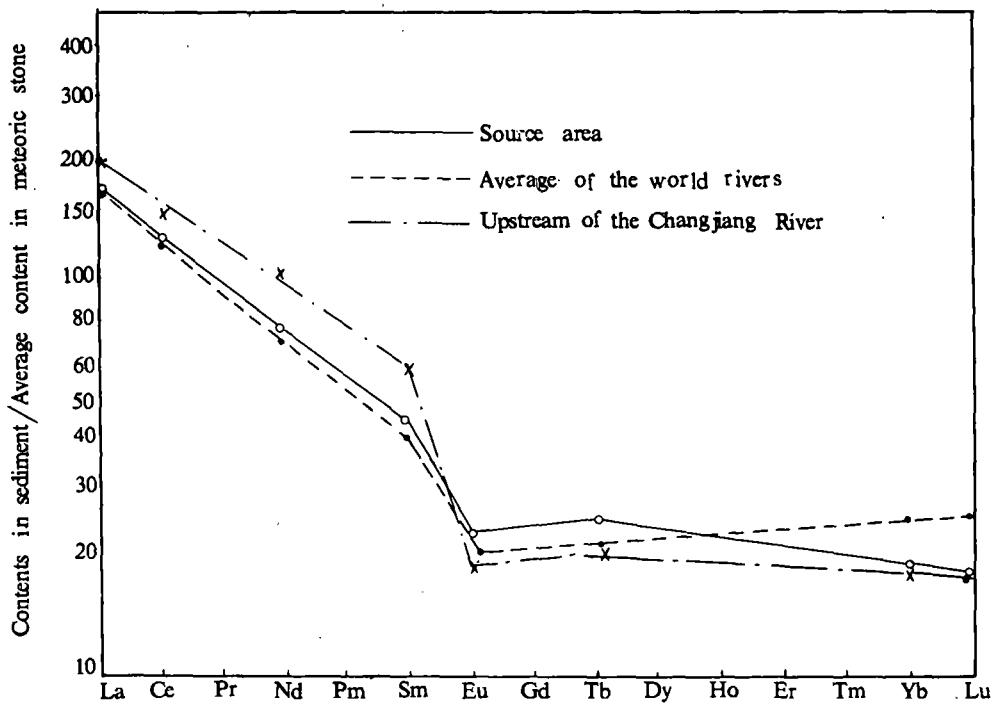


Fig.2 Distribution patterns of rare -earth and radioactive elements in sediment

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