A Neutron Activation Study of the Geochemistry of Natural Water in Lhasa, Tibet, China

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Abstract

Rainwater, river water, and groundwater were sampled from Lhasa, Lhasa He River, and the surrounding areas. They were analysed by the neutron activation method. Traces of Al, Ba, Br, Ca, C1, Co, Cs, Cr, K, Lu, Mn, Mg, Na, Rb, Sb, Sc, Sm, V and Zn were detected in all types of water; Ce, Fe, Hf, La, Mo, Sr, Th, and U were detected in river water and groundwater; and Nd was detected only in groundwater. The concentrations of elements in Lhasa water sources were compared with those of fresh-water bodies worldwide, as reported by Bowen (1979). They were also compared with water sampled simultaneously from nine other sites distributed in various climatic regions of China.

Introduction

Water is a resource circulated throughout all ecosystems and is one of the most important factors of them (Odum 1971). From the point of view of ecohydrology, for the main elements of an ecosystem including inorganic and organic compounds, producers, and macro- and micro-consumers, both the quantity and the chemistry of water have a decisive impact on its biomass and biotic composition. Information obtained from current hydrochemical analyses of water specimens is very important, but it is sometimes difficult to gauge the overall situation, especially the ocurrence of rare elements which may be very important to an ecosystem. The purpose of this work is to provide preliminary observations of the geochemistry of natural water from Lhasa and to make geochemical comparisons between Lhasa water and water from other regions of the country.

Materials and Methods

Site and Sampling

Rainwater was sampled from Lhasa Hydrological Experimental Station which is located at 23° 39' N and 91° 09' E at an altitude of about 3,660masl. The annual mean precipitation is as measured (452.5mm) from 1953 to 1979. River water was sampled from the Lhasa He River. With a drainage area of 26,225sq.km., it

originates in the Nyainqentanglha Mountains to the north of Lhasa and flows as an affluent of the Yarlung Zangbo River to the north of the Himalayas. Phreatic groundwater was sampled from drinking wells situated in the plain of the Lhasa River valley.

Natural water, including rainwater, river water, and groundwater, was sampled simultaneously at ten hydrological stations in various climatic and geomorphological regions of the country, of latitudes from 20° 02' N (Haikou) to 47° 21' N (Qiqihar), altitudes from 5masl (Tianjin) to 3,660masl, (Lhasa), and with annual mean precipitations ranging from 34.5mm (Hetian) to 1,571mm (Haikou) in arid and humid regions respectively.

Analyses

Water samples were cleaned, a portion of them being passed through a millipore filter for removing of suspended particles. Samples were preconcentrated by freeze-drying and evaporated by the vacuum method in a laboratory at Nanjing University. The dried samples, standard reference materials, and a blank plastic bag (the container of dried samples) were irradiated simultaneously in a heavy-water cooled nuclear reactor for 20h with a thermal neutron flux of 30 billion n per cm^2 per second. Activated elements and their concentrations were determined with a spectrometer (Soete et al. 1972).

Results and Discussion

Rainwater

The nineteen elements, A1, Ba, Br, Ca, C1, Co, Cr, Cs, K, Lu, Mg, Mn, Na, Rb, Sb, Sc, Sm, V, and Zn, were detected in the rainwater of July 1989. This was the least number of elements detected in rainwater sampled in the same period from all ten stations distributed in the various climatic regions of China mentioned above. By comparison, 31 elements were detected in Qiqihar.

The concentrations of Ba, Cs, and Mn were the highest from all these stations, and those of Sc the lowest. The occurrences of eleven elements, including some from the rare-earth family and other rare elements, were higher than the median contents of reported fresh-water bodies worldwide (Bowen 1979), as shown in Figure 1. This is indeed a special composition of rainwater elements. It is also worthy of notice that the presence of Ba, Lu, and Zn was among the highest range of any reported freshwater sources. Element concentrations in rainwater are classified in Table 1.

River water

During the two years, 1988 - 1989, 27 elements — Ce, Fe, Hf, La, Mo, Sr, Th, U and those found in rainwater — were detected in the Lhasa He River. Surprisingly, traces of Cs and Cr were the highest ones within river water samples taken in the same periods from all ten rivers in China, including the

Yangtze River at Nanjing, the Yellow River at Yinchuan, and the Nen Jiang River at Qiqihar.

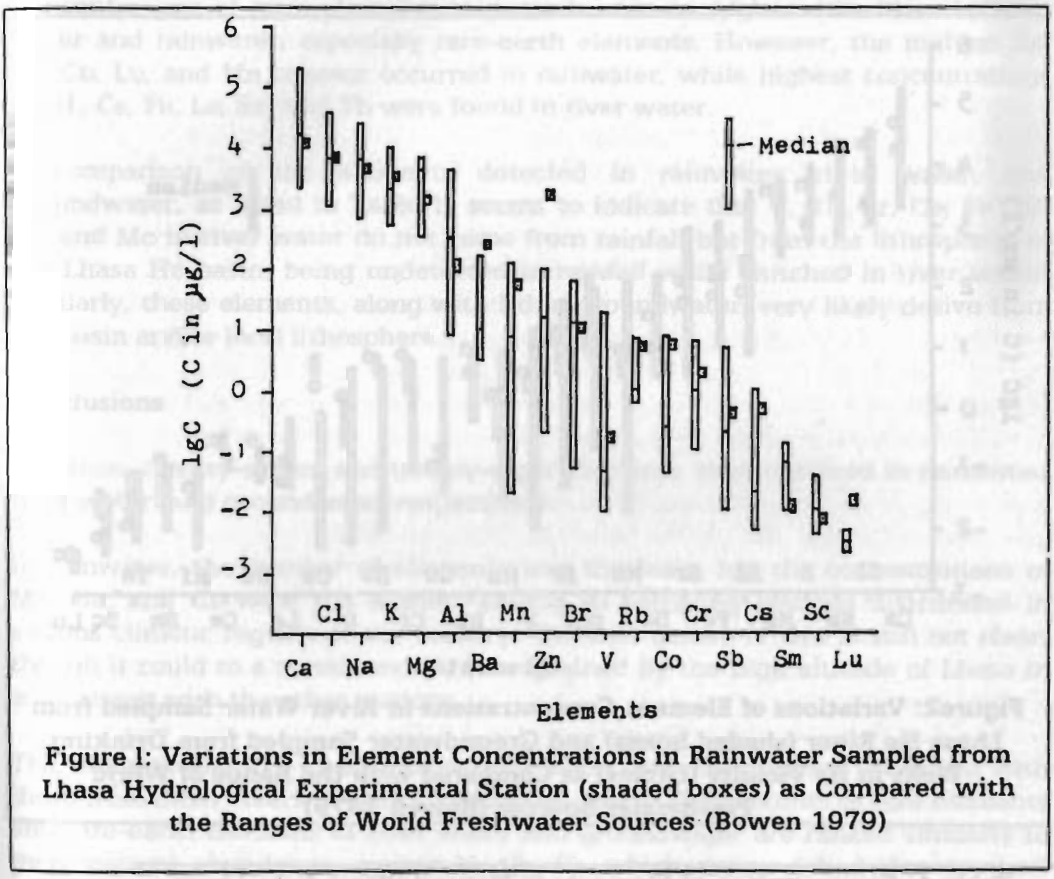

Figure 1: Variations in Element Concentrations in Rainwater Sampled from Lhasa Hydrological Experimental Station (shaded boxes) as Compared with the Ranges of World Freshwater Sources (Bowen 1979)

Many elements, including Ce, Cr, Cs and V, showed somewhat higher concentrations than the median values of reported fresh-water bodies, while the concentration of Cs was 200 - 397 times more (Fig. 2).

In flood season, July, of the same two years, it was found that the presence of Cs, U, and Zn increased significantly in 1989: the concentration (ppb) of U on 20 July, 1988, 30 July, 1988, and 15 July, 1989, was 0.230, 0.754 and 1.28 respectively, while that of Zn was 7.52, 9.75 and 189 respectively. The element concentrations are shown in Table 1.

Groundwater

Groundwater contains all the elements detected in rainwater and river water, with additional n.d. There are 15 elements with concentrations higher than the median values of Bowen (1979), as shown in Fig. 2. The natural abundance of rare elements and rare-earth elements in the earth's crust ranks as follows: Sr> Ba> Rb> Ce> La> Nd> Sc> Sm> Th> U> Cs> Lu> Sb. In the groundwater of Lhasa analysed for this study, this ranking in general persisted, but the

elements U, Cs, and Sb, which are easily transported, were enriched and moved up the ladder.

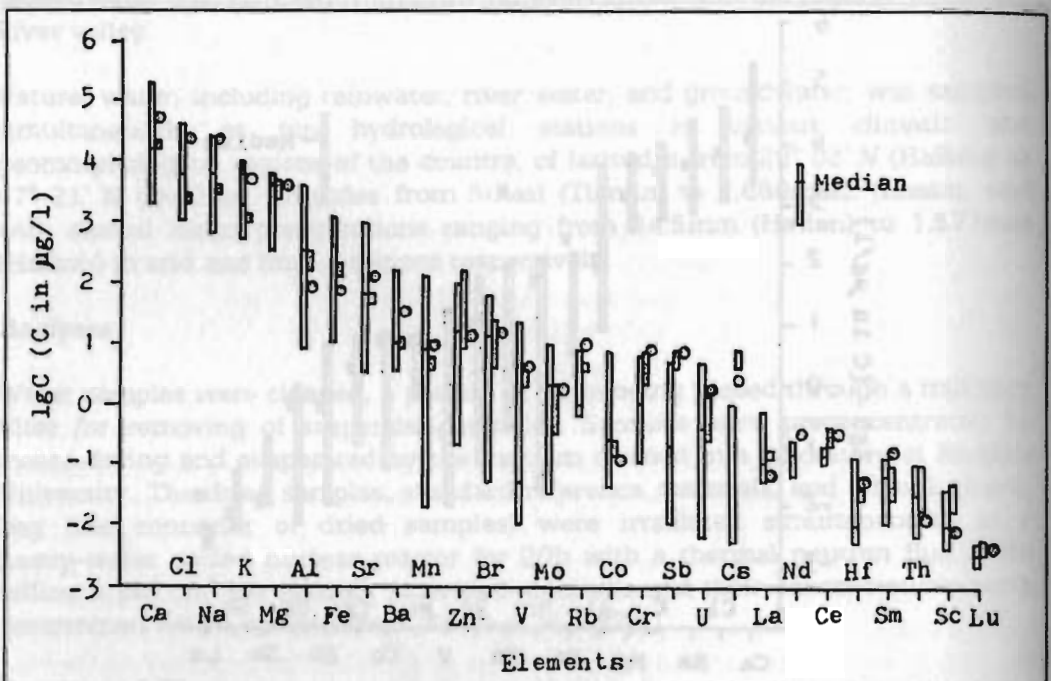

Figure2: Variations of Element Concentrations in River Water Sampled from Lhasa He River (shaded boxes) and Groundwater Sampled from Drinking Wells in Its Vicinity (circles) as Compared with the Range of World Freshwater Sources (Bowen 1979)

Table 1: Concentration of Elements in Natural Water from Lhasa

Concentration (μg/l)	Elements detected in					
	Rainwater	River water		Groundwater		
	1	1	2	1	2	3
$>10^4$	Ca	Ca		Ca Cl Na		
10^3 - 10^4	Cl	Cl		Mg		
	Mg	Mg		K		
	Na	Na				
	Zn					
10^2 - 10^3	Al	Al	Fe		Sr	
	Ba					
	K	K				
10 - 10^2	Br		Sr	Al Ba Br	Fe	
	Mn			Zn		
1 - 10	Cr	Ba Br Cr Cs		Mn Cr Cs		
	Rb	Mn Rb Zn		Rb	U	
0.1 - 1	Co	Co	Ce	V	Ce	Nd
	Cs		La	Co		
	Sb	Sb	Mo	Sb		
	V	V	U	Sm		
0.01 - 0.1	Lu	Sc	Hf		Hf	
		Sm	Th		Th	
					La	
<0.01	Sc	Lu		Lu Sc		
	Sm					

Comparison between Water Types

Concentrations of most elements in groundwater are higher than those in river water and rainwater, especially rare-earth elements. However, the highest Zn, Ba, Co, Lu, and Mn content occurred in rainwater, while highest concentrations of A1, Cs, Fe, La, Sc, and Th were found in river water.

A comparison of the elements detected in rainwater, river water, and groundwater, as listed in Table 1, seems to indicate that U, Th, Sr, Ce, Fe, Hf, La, and Mo in river water do not come from rainfall but from the lithosphere of the Lhasa He basin, being undetected in rainfall while enriched in river water. Similarly, these elements, along with Nd in groundwater, very likely derive from the basin and/or local lithosphere.

Conclusions

Nineteen, twenty-seven, and twenty-eight elements were detected in rainwater, river water, and groundwater respectively.

In rainwater, the number of elements was the least, but the concentrations of Mn, Ba, and Cs were the highest among all sampling stations distributed in various climatic regions of the country. The mechanism of this is still not clear, though it could to a certain extent be explained by the high altitude of Lhasa in comparison with the other stations.

The concentrations of Cs and Cr in river water were the highest compared with those from other rivers in China during two years. The contents of rare elements and rare-earth elements of river water and groundwater are ranked similarly to their natural abundance, except U, Cs, Sb which are enriched due to their moving character in the water environment. It also concluded that elements U, Th, Sr, and some others in river water and groundwater are sourced mainly from the basin / local lithosphere.

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