

ANALYSIS OF ANTARCTIC LAND WATER SYSTEMS BY NORMALIZATION WITH CHLORIDE ION CONCENTRATION: A NEW ATTEMPT TO ANALYZE WATER SYSTEMS
(EXTENDED ABSTRACT)

Kunihiko WATANUKI

*Department of Chemistry, the College of Arts and Sciences, the University of Tokyo,
8-1, Komaba 3-chome, Meguro-ku, Tokyo 153*

In limnology, chemical composition of water system is analyzed by various methods. For example, a key diagram as shown in Fig. 1 is often used to classify the chemical types of water systems. In the diagram, each chemical component is plotted as millival % (milliequivalent percentage). Water systems are divided into five types, such as ground water (I), thermal water (II), sea water (III), surface water (IV) and intermediate water (V). The key diagram is suitable to identify the water type, but it shows only the relative chemical component pattern.

A triangular diagram as shown in Fig. 2 is also used to show characteristics of chemical composition of a water system. To analyze Antarctic land water system, a Ca-Mg-(Na+K) diagram was used to elucidate the evolution of the water system under the frigid environment (TORII *et al.*, 1981).

In the diagram, each chemical component is given in millival %. In order to know the chemical features, a key diagram is usually used together with an anion triangular diagram Cl-SO₄-HCO₃ and a cation triangular diagram.

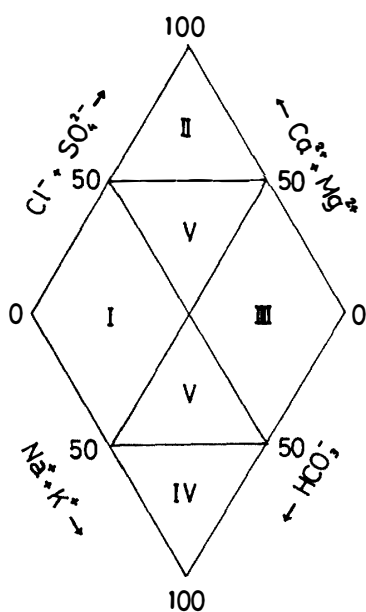


Fig. 1. Key diagram.

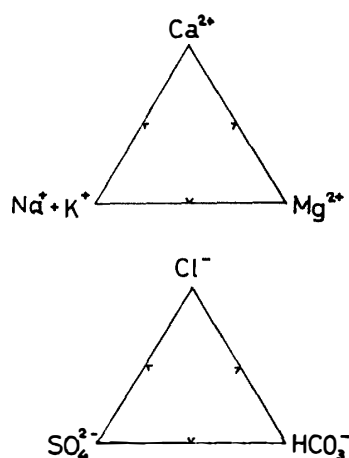


Fig. 2. Triangular diagram.

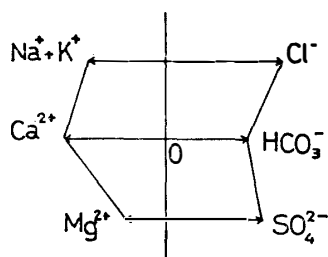


Fig. 3. Hexa diagram.

diagram can show the relative chemical component pattern only. A hexa diagram which is shown in Fig. 3, is also used to analyze water quality in nature. This type of diagram is used only to recognize the relative pattern of the water systems.

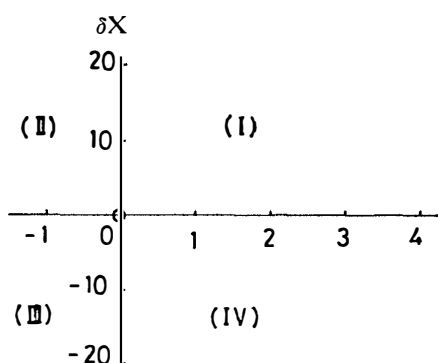
Recently, the concentration correlation matrix method was developed to analyze correlation among the samples for environmental research (ANDERS, 1972). The present author tried to analyze Antarctic land water systems by using the concentration correlation matrix, and discovered high relation among the Antarctic water systems, such as sea water and water of Lake Nurume and so on (WATANUKI, 1977). In the concentration correlation matrix, the ratio of the concentration of chemical component is used to analyze the water system, so that the concentration factor is cancelled and only the normalized relative value can be expressed in numerals.

In this paper, the author tries to analyze water system by introducing a new coordinate. First, the author defined δX as in the following eq. (1).

$$\delta X = \frac{(X/Cl)_s - (X/Cl)_r}{(X/Cl)_r} \times 100, \quad (1)$$

where s means sample and r is reference sea water, X denotes concentration of component X, and Cl is the concentration of chloride ion in the water. For chloride ion, δCl is defined as the following eq. (2).

$$\delta Cl = \left(\frac{Cl_s}{Cl_r} \right) - 1, \quad (2)$$



○ sea water

Fig. 4. δX - δCl diagram.Table 1. Relation of plotted position and δX , δCl .

Area code	δX	δCl
I	+	+
II	+	-
III	-	-
IV	-	+

δX and δCl calculated on each sample are plotted on the diagram δX - δCl as shown in Fig. 4.

When chloride ion concentration is less than that of sea water, δCl can be plotted between -1 and 0 in the diagram. The position of abscissa denotes the chloride ion concentration in the sample water. And the position of ordinate denotes relative concentration of other elements normalized with chloride concentration.

The relation between plotted position and δCl , δX is shown in Table 1.

In this diagram, we can easily recognize the real chloride concentration in the water. And the relative concentration of the other chemical species can be compared with that of sea water.

Some calculated results are shown in Tables 2 and 3. From the data, it is easily seen that chloride concentration in the water of Lake Hunazoko is 6.14 times larger than that of sea water. And relatively low concentrations of Na^+ , Ca^{2+} and SO_4^{2-} show the removal of these ions by deposition of mirabilite and gypsum.

As seen in Table 3, the salt content of Lake Vanda and ground water beneath the lake bottom is considerably different, but differences from sea water in chemical components resemble each other. This may mean that these two Antarctic water systems have the same origin and evolution.

Table 2. Chemical composition and δX of Lake Hunazoko.

	K ⁺	Na ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	SO ₄ ²⁻	
	2.4	58.2	2.2	7.8	116	2.47	g/kg
δX	3.0	-10.3	-9.5	0.3	5.14	-84	%

Table 3. Chemical composition and δX of some water systems in the Antarctic.

	K ⁺	Na ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	SO ₄ ²⁻	
(1)	6.5	0.74	22.7	7.17	72.2	0.64	g/kg
δX	-0.84	-0.49	13.9	0.48	2.8	-0.94	%
(2)	8.75	1.08	33.2	10.5	108.7	0.248	g/kg
δX	-0.85	-0.50	14.5	0.44	4.75	-0.98	%

(1) Water of Lake Vanda 63 m (YAMAGATA *et al.*, 1967).

(2) Ground water of Lake Vanda 75.7 m (TORII *et al.*, 1974).

References

- ANDERS, O. U. (1972): A statistical aid for discovering generic relationship among samples. *Anal. Chem.*, **44**, 1930-1933.
- TORII, T., NAKAI, N., MORIKAWA, H., ONO S. and NAKAYAMA, K. (1974): Preliminary report on the Japanese research work in phase III of DVDV. *DVDV Bull.*, **3**, 149-155.
- TORII, T., MURATA, S. and YAMAGATA, N. (1981): Geochemistry of the Dry Valley Lakes. *J. R. Soc. N. Z.*, **11**, 387-393.
- WATANUKI, K. (1977): Ta-seibun nōdo sōkan ni yoru Nankyoku suikei no kaiseki (Analysis of Antarctic water systems by concentration correlation matrix). *Nankyoku Shiryō (Antarct. Rec.)*, **58**, 131-137.

YAMAGATA, N., TORII, T. and MURATA, S. (1967): Report of the Japanese summer parties in Dry Valleys, Victoria Land, 1963–1965. V. Chemical composition of lake waters. Nankyoku Shiryô (Antarct. Rec.), **29**, 53–75.

(Received May, 9, 1985; Revised manuscript received June 21, 1985)