Report of the Japanese Summer Parties in Dry Valleys, Victoria Land, 1963-1965

VII. Chemical Composition of Pond Waters in Ross Island with Reference to Those in Ongul Islands

Noboru YAMAGATA*, Tetsuya TORII**, Sadao MURATA**
and Kunihiko WATANUKI***

南極 Victoria Land の Dry Valley 調査報告

VII. Ross 島と Ongul 島の池水の化学成分の比較

山 県 登*・鳥 居 鉄 也**・村 田 貞 雄**
綿 抜 邦 彦***

要　旨

Ross島における1964年1月の調査と，第6次南極地域観測における Ongul 島の調査によって得られた池水の化学分析を行なった その結果を海水に対する各イオンの濃縮係数の差によって陸水の性質を考察する菅原らの方法によって検討したところ，いわゆる南極Ongul島池水型とも称すべき

SO_4, Na<Cl<K, Mg<Ca, Sr<I

からはずれる多くの水を見出し，このような分類法は適当でなく，むしろ各イオン対について比較するにとどめ

Cl<SO_4,　Na<K,　Mg<Ca

をより一般性のある分類法とすべきことを提唱した

Introduction

Taking advantage of the visit to Victoria Land, Antarctica, some of the Japanese scientists made reconnaissance in Ross Island and collected pond waters for chemical analysis. The purpose was, on the one hand, to search for a key to solve the problems of the saline lakes in Victoria Land, and, on the other hand, to relate the result with that of some recent works conducted in collaboration with the Japanese Antarctic Research Expedition in East Antarctica.

Chemical composition of various types of water substances was determined by several workers for the samples collected in the vicinity of Syowa Station on the

*国立公衆衛生院. The Institute of Public Health.
**千葉工業大学. Chiba Institute of Technology.
***東京大学教養学部. College of General Education, the University of Tokyo.

East Ongul Island (SUGAWARA and TORII, 1959; SUGAWARA, 1961; MINAMI *et al.*, 1961). Among the waters examined by them, the salt content and the composition of pond waters have been interpreted as a mixture of meteoritic water and wind-blown spray of sea water. In the present report, the chemical composition of waters from ponds and pools in the coastal areas is compared with that of sea water, with special emphasis on the method of classification based on the enrichment coefficient.

Results and Discussion

All the samples from West Antarctica were collected in January 1964 in Ross Island, except for one from Stranded Moraines on the Continent opposite to

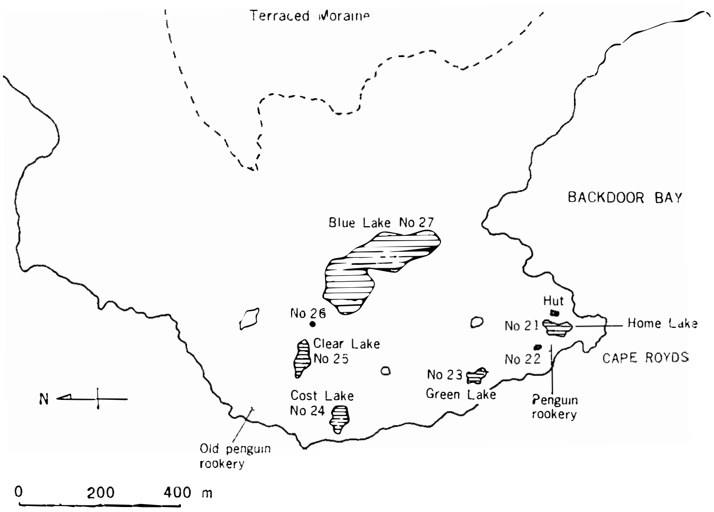

Fig. 1. Cape Royds, Ross Island.

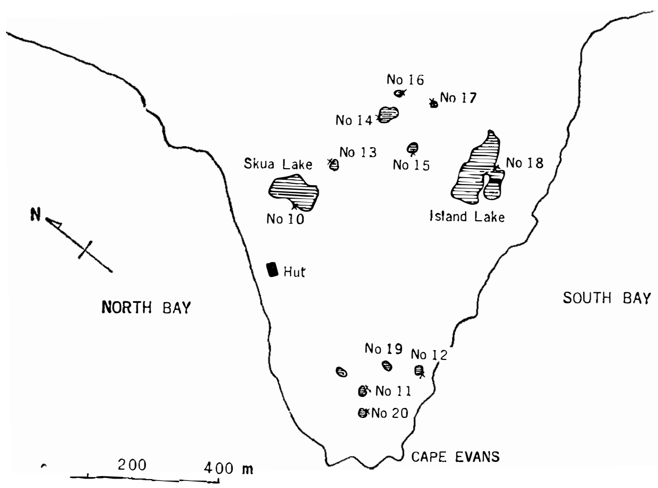

Fig. 2 Cape Evans, Ross Island.

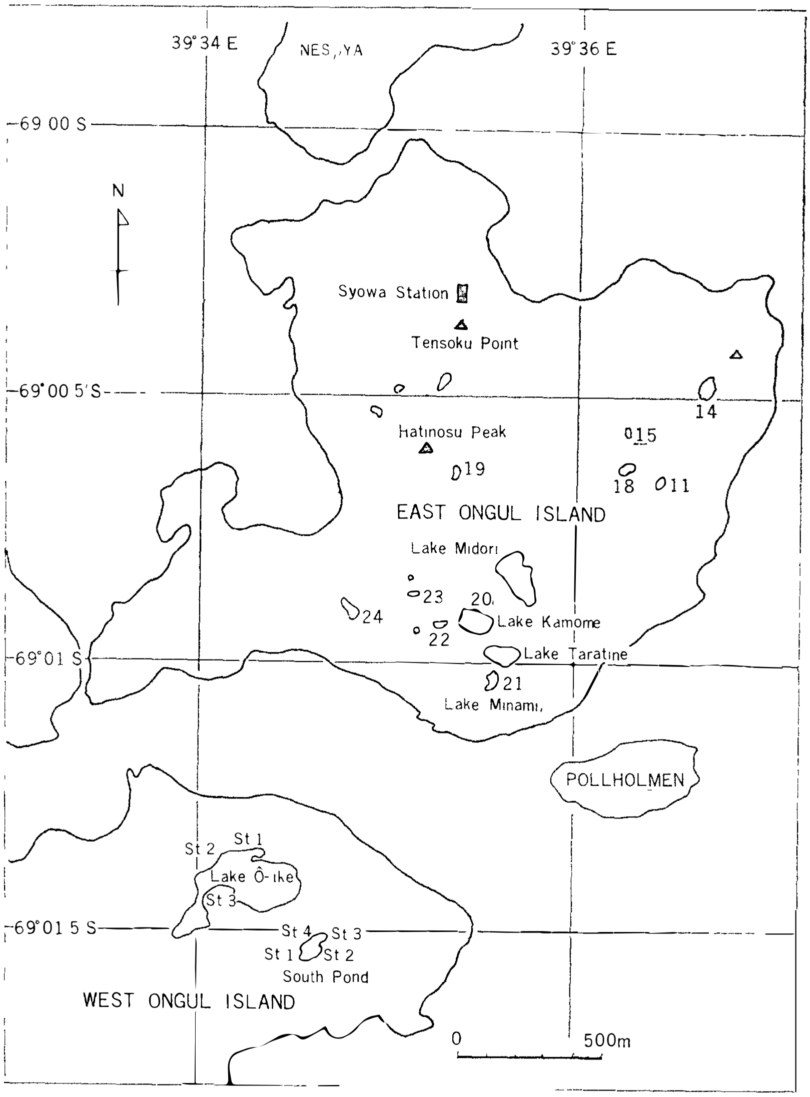

Fig. 3 Ongul Islands.

McMurdo Station (lat. 77°45′S). Waters were taken from Home Lake (No. 21), an unnamed pond (No. 26) and Blue Lake (No. 27) at Cape Royds, Skua Lake (No. 10), Island Lake (No. 18) and four unnamed ponds (Nos. 15, 17, 19 and 20) at Cape Evans. Samples from East and West Ongul Islands were collected in January 1962 by WATANUKI who joined the 6th Japanese Antarctic Research Expedition (1961–62). Localities of the ponds and lakes are shown in Figs. 1–3 and the results of chemical analysis and field data in Tables 1 and 2.

The chloride content of waters varied largely, the highest value being about 6 g/l in pond No. 20 at Cape Evans, and five of eleven ponds in Ross Island and one of thirteen in Ongul Islands showed higher chloride contents than 1 g/l. Altogether, only four ponds showed concentrations of chloride far below 100 mg/l. Only a little is known of the chemical composition of precipitation in the polar

Table 1. Chemical analyses of fresh waters in Ross Island

Locality	Time of collection	Water temperature (°C)	Na (mg/l)	K (mg/l)	Mg (mg/l)	Ca (mg/l)	Cl (mg/l)	SO_4 (mg/l)
Cape Royds								
No. 26	Jan. 14, 1964	4.80	2,460	264	228	55.2	3,891	674
Home Lake	〃	3.40	905	64	59.6	28.4	1,061	708
Blue Lake	〃	0.05	15.5	3.2	0.9	1.1	30.5	0
Cape Evans								
Skua Lake	Jan. 9, 1964	5.80	108	9.6	15.4	7.1	221	41
No. 15	〃	5.40	1,600	10.1	106.4	38.5	1,549	313
No. 17	〃	4.50	2,550	12.5	129.7	55.4	2,406	644
No. 18	〃	2.20	480	17.7	37.3	18.6	540	465
No. 19	〃	3.65	1,800	72.0	183.8	80.0	2,782	867
No. 20	〃	3.30	3,710	203	395	156	6,042	1,140
McMurdo Crater	Dec. 25, 1963	1.00	–	–	1.4	4.0	18.9	2
Stranded Moraines	Jan. 10, 1964	0.25	10.5	1.9	1.0	7.9	26.7	1

Table 2. Chemical analyses of fresh waters in Ongul Islands.

Locality	Time of collection	Air temp. (°C)	Water temp. (°C)	pH	Electric resistance (×10³ ohm/cm)	Na (mg/l)	K (mg/l)	Mg (mg/l)	Ca (mg/l)	Cl (mg/l)	SO_4 (mg/l)
West Ongul Is.	Jan. 21, 1962										
Lake Ô-ike St. 1		3.0	5.0	6.8	5.1	51.0	2.6	7.1	5.6	101	12.8
St. 2		3.0	4.0	6.7	5.4	49.5	2.6	7.2	5.3	99.8	13.1
St. 3		3.0	7.0	7.0	5.5	51.1	2.5	7.2	5.4	100	13.1
South Pond St. 1		2.5	7.0	7.3	3.5	63.4	3.0	9.3	9.3	118	31.3
St. 2		2.5	5.5	7.3	3.5	68.0	3.6	10.0	9.1	134	27.3
St. 3		2.5	6.0	7.3	5.8	47.5	2.4	5.8	3.7	95.6	18.8
St. 4		2.5	5.5	7.4	6.0	44.3	2.4	4.1	3.5	91.6	17.8
East Ongul Is.											
Pond No. 11	Jan. 22, 1962	−1.0	4.0	7.1	3.2	101	5.0	6.0	3.9	159	24.4
No. 14	〃	−1.0	5.2	7.1	1.3	231	9.9	20.9	15.4	373	84.5
No. 15	〃	−1.0	4.0	7.0	1.1	260	12.0	30.4	17.8	464	72.2
No. 18	〃	−1.0	4.0	7.0	3.7	94.0	4.4	8.9	5.8	167	28.9
No. 19	Jan. 23, 1962	2.0	3.0	7.0	1.0	231	12.1	34.1	24.0	389	157
No. 20	〃	3.0	10.0	7.0	2.2	92.6	4.2	14.1	9.6	185	14.7
No. 21	〃	3.0	11.0	7.0	0.46	499	26.1	66.3	47.6	1,005	119
No. 22	〃	3.0	14.0	7.1	4.0	49.1	2.6	3.8	3.6	84.2	31.3
No. 23	〃	3.0	15.0	7.0	4.5	47.5	2.5	4.4	3.8	85.1	12.4
No. 24	〃	2.5	15.2	7.0	3.5	63.5	2.8	7.0	5.3	110	46.5
No. 7	Jan. 19, 1962	–	–	–	–	15.0	1.1	2.3	0.75	26.3	14.2

Photo 1 Skua Lake at Cape Evans

regions, but some data indicate a large variety of chloride content. ANGINO *et al.* (1965) reported the highest chloride content 561 ppm and down to 14 ppm or even less in glacier ice. SUGAWARA (1961) reported 414 and 8.3 ppm in snow and 996 and 3.4 ppm in pack-ice in Antarctica. The waters from Blue Lake, Cape Royds, Crater pool, McMurdo, Stranded Moraines and pond No. 7 in East Ongul Island are characterized by low chloride content, some ten ppm, and the waters seem to be more closely related to snow- or ice-melt in nature than the other pond waters of higher chloride content. In fact, in most of these ponds, water was supplied by snow- or ice-melt from adjacent area at the time of our visit.

After SUGAWARA (1961), the chemical characteristics of water substances are well demonstrated by comparing the ratios of various ionic components to chlorine with those for sea water. Thus, the enrichment coefficient in water is defined as (M/Cl in water)/(M/Cl in sea water) where M is an ionic component Sea-spray in known to be enriched, in the course of its formation and transportation, with different ionic components to different degrees. The enrichment coefficient of sea-spray is believed to increase in the following sequence:

$$Na < Cl,\ Ca,\ Sr < SO_4,\ Mg < I \quad \cdots \quad (1)$$

If, the salt in a pond water is solely originated in sea-spray, the enrichment coefficient of the water should vary in the above-mentioned manner.

In Table 3 are summarized the enrichment coefficients for the cations sodium, potassium, magnesium and calcium and the anion sulfate in the pond waters. The enrichment coefficients for sodium are very close to the unity in the pond waters of Ongul Islands, the average being 0.93, while in Ross Island, the value has a wider range 0.71–1.92, the average being 1.28. A similar trend is found also in the ratio K/Cl with comparatively smaller variation in Ongul Islands than in Ross Is-

Table 3. Enrichment coefficients for several elements relative to chlorine in comparison to sea water composition (M/Cl pond water/M/Cl sea water)

Pond	Enrichment coefficient				
	Na	K	Mg	Ca	SO_4
Cape Royds					
No. 26	1.14	3.5	0.88	0.67	1.23
Home Lake	1.54	3 0	0.84	1.27	4.7
Blue Lake	0 91	5.1	0.41	1.55	–
Cape Evans					
Skua Lake	0.88	2.2	1.04	1.50	1 31
No. 15	1.86	0.3	1 03	1.18	1 43
No. 17	1.92	0 3	0 80	1.10	1.90
No 18	1.60	1 6	1.03	1.63	6 1
No. 19	1.16	1.3	0.99	1.36	2 22
No. 20	1 11	1.7	0.98	1.23	1.35
McMurdo Crater	–	–	1.18	1.02	0.76
Stranded Moraines	0 71	3.7	0.55	1.39	2.7
West Ongul Is.					
Lake Ô-ike St. 1	0.91	1.30	1.02	2.62	0.90
St 2	0.90	1.31	1.05	2.52	0.92
St. 3	0.92	1.26	1.05	2 57	0.93
South Pond St. 1	0.97	1.28	1.15	3.75	1.83
St. 2	0 92	1.34	1 09	3.21	1 44
St. 3	0.90	1.25	0.88	2.54	1.39
St. 4	0.88	1.36	0 89	2.54	1.38
East Ongul Is.					
No. 11	1.14	1.57	0.55	1 18	1.09
No. 14	1.12	1.33	0 82	1 95	1 58
No. 15	1.01	1.29	0.90	1.82	1 08
No. 18	1.01	1.32	0 78	1.63	1.22
No. 19	1.07	1.55	1 28	2.92	2.86
No. 20	0.90	1.13	1 12	2.46	0.58
No. 21	0.90	1.30	0.97	2.24	0 83
No. 22	1.05	1.56	0 66	2 04	2 64
No. 23	1.01	1 47	0.67	1.90	0 92
No. 24	1 04	1.28	0.94	2.27	3.00

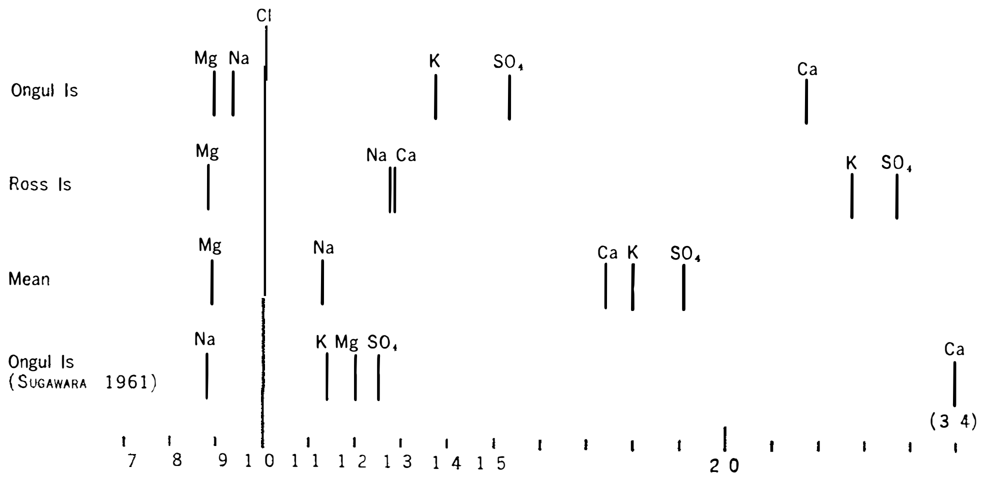

Fig 4 Enrichment coefficients in fresh waters in Antarctica

land, but in both localities, the average coefficient for potassium is larger than for sodium, namely, 1.37 in the former and 2.27 in the latter island.

The variations in the coefficients for magnesium and calcium seem to be larger than in those for the alkali metal elements, and the variation for sulfate ion is still larger. The average coefficient for magnesium is smaller than the unity, and the values for Ongul and Ross Islands are quite similar, 0 89 and 0.88, respectively. In contrast, the coefficients for calcium are considerably larger than the unity, especially in Ongul Islands where the average is 2.17 (1.27 in Ross Island). Some of the ponds show smaller coefficients for sulfate than the unity, but in most cases the enrichment coefficients are very large, the highest value being 6 1 in pond No. 18 at Cape Evans, and the averages are 1.52 and 2.37 respectively for Ongul and Ross Islands.

The results visualized in Fig. 4, in which are shown the average coefficients in each of Ongul and Ross Islands and the over-all average, indicate discrepancies not only between the two localities but also with the result obtained by SUGAWARA for pool waters in Ongul Islands.

Several investigators intend to classify fresh waters into groups by the sequence of enrichment coefficients. Thus, the type "pool water in Ongul Islands" was expressed as

$$SO_4,\ Na < Cl < K,\ Mg < Ca,\ Sr < I \quad \cdots\cdots\cdots\cdots\cdots (2)$$

and was differentiated from the "sea-spray" type (1) (SUGAWARA, 1961). However, such classification seems to be based on insufficient data and this fact, together with the wide variation found among waters even within a small area, would suggest the presence of other factors which might affect the sequence of enrichment coefficient after deposition of precipitation and sea-spray.

The present result would never contradict the "sea-spray" type fresh waters in

Antarctica if the type is defined as follows by comparing the enrichment coefficients only between pairs of ions:

$$Cl < SO_4,\ Na < K \text{ and } Mg < Ca \cdots\cdots (3)$$

This way of classification seems to be more practical at the present time when much is left uncertain as to the mechanism of geochemical cycle which takes place in hydro- and biospheres.

References

ANGINO, E. E., K. B. ARMITAGE and J. C. TASH: Ionic content of Antarctic ice samples. Polar Rec., **12**, 407–409, 1965.

MINAMI, E., T. MATSUMOTO and J. OSSAKA: On the puddle waters in the vicinity of Ongul Island, Antarctica. Antarctic Rec., **11**, 121–127, 1961.

SUGAWARA, K.: Chemistry of ice, snow and other water substances in Antarctica. Antarctic Rec., **11**, 116–120, 1961.

SUGAWARA, K. and T. TORII: Chemical composition of the waters of some ponds on the East Ongul Island, Antarctica. Antarctic Rec., **7**, 53–55, 1959.

(*Received May 25, 1967*)