*On the Main Chemical Components dissolved in the Adjacent Waters to the Aleutian Islands in the North Pacific**

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Introduction

The authors have studied the main components dissolved in the sea water collected in the region adjacent to the Aleutian Islands. The chemical components dealt with in this paper are chloride, sulfate, sodium, magnesium, calcium and potassium ions.

Since Dittmar¹⁾ reported the composition of oceanic salt obtained from various regions of the world, it has been well known that the abundance ratios between main ions dissolved in sea water are in good agreement for any locality of the whole ocean. Nevertheless, it has been also known that there are some exceptional cases where slight dis-

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1) W. Dittmar, "Challenger Report, Physics and Chemistry", Vol. 1 (1884).

agreement is found due to local circumstances such as inflow of a large river or explosion of a submarine volcano. At the present step of chemical oceanography, it is to such a local difference in the main dissolved components that attention has been called.

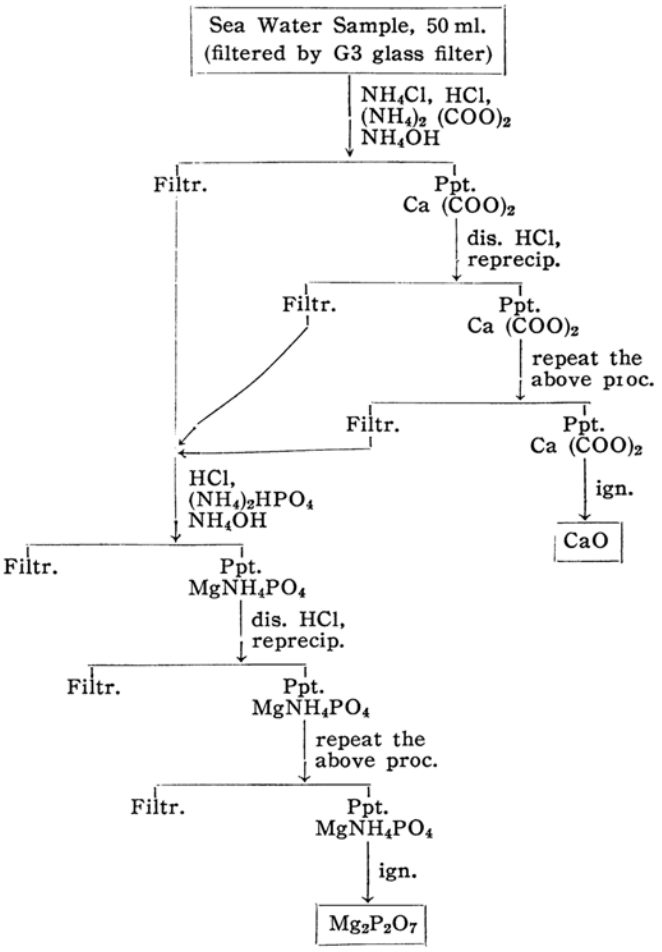
The region under study is located in the north end of the North Pacific, as shown in Fig. 1 of the previous report²⁾, being under the effect of polar conditions. In this paper, the authors mainly examined whether or not the ratios between the main components in the waters of this region show any difference when compared with those in other regions. Investigations concerning the subject in the region under study have scarcely been carried out except in the case of that made by Ratomanov et al³⁾, which seems to involve some results to be reexamined.

Samples and Analytical Methods

As mentioned in the previous report, a marked minimum of water temperature is found in the region in question at a depth of about 100 m. It may accordingly be expected that the deviations from the normal values of the ratios between the main dissolved components presumably would be centered at the depth, if the deviations should be caused by freezing or other phenomena relating to low temperature. For this reason the following samples were selected from those collected in the areas under study, the Bering Sea area and the North Pacific area, keeping the above view in mind. They are respectively water samples from the surface layer (10–25 m.), the temperature minimum layer (75–100 m.) and the deep layer (about 1000 m.) in each area. Each sample was prepared by mixing equally water samples collected at several stations situated in the same area. In addition to these, two surface water samples were analyzed, one of which was

TABLE I

SCHEMES OF SEPARATION PROCEDURES FOR CALCIUM AND MAGNESIUM



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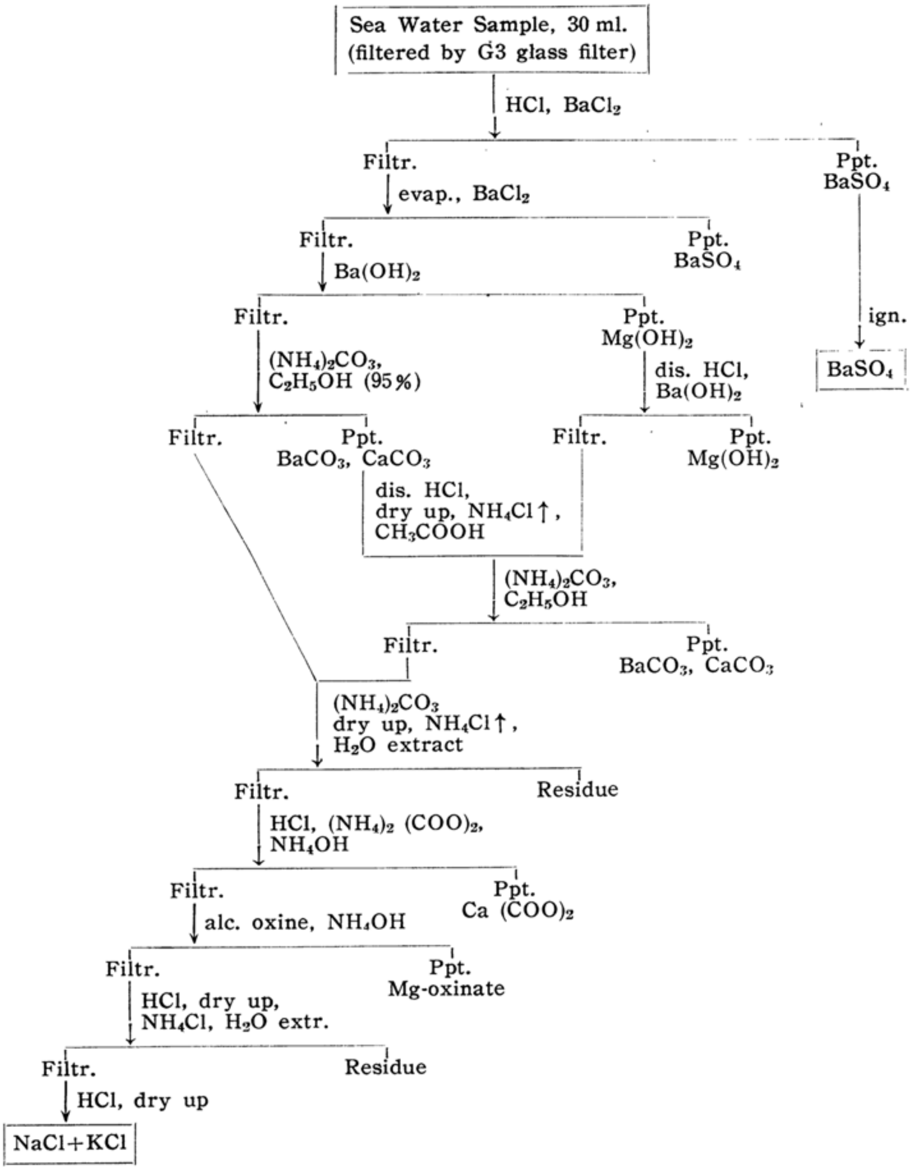
[2] R. Fukai, This Bulletin, 27, 402 (1954).

[3] C.E. Ratomanov et al, "Research of the Sea", Vol. 2, Moscow, 1936 (in Russian with English summary).

TABLE II

SCHEMES OF SEPARATION PROCEDURES FOR SULFATE, SODIUM AND POTASSIUM



obtained in the vicinity of an island and the other at Station 24 (just above Bowers Bank where upwelling was taking place).

Gravimetric methods of analysis have been adopted for all components except for chlorine determination. Ordinary procedures have been followed so that strict comparison with former data can be made. Outlines of procedures are shown schematically in Tables I and II. Accidental errors have been avoided by means of checking analyses from time to time on artificial sea water containing known quantities of each component.

Total amounts of alkali metals were determined as chlorides and potassium was precipitated by

TABLE III

PERCHLORATE METHOD FOR SEPARATION OF ALKALI METALS COMPARED WITH CHLOROPLATINATE METHOD

Method		K mg. (added)	K mg. (found)	
			Perchlorate	Chloroplatinate
KCl	solution	13.04	13.03	13.30
		〃	12.77	13.03
KCl+NaCl	solution	13.04	13.21	13.34
		〃	13.18	

added NaCl: 842 mg.

perchloric acid instead of chloroplatinic acid. No significant difference was recognized between the values obtained by these two different methods as shown in Table III.

Results and Discussion

Analyses have been carried out two or three times for each sample and the averaged values obtained are given in Table IV in terms of ratios to chlorinity.

TABLE IV

RESULTS OF ANALYSES IN TERMS OF RATIOS TO CHLORINITY

Location and Depth	Cl ‰	SO_4	Na	K	Mg	Ca
Aleutian Region						
Bering Sea Area						
surface	18.38	0.14054	0.5554	0.02090	0.06625	0.02137
temp. min. 100 m.	18.51	.13853	.5544	.02087	.06601	.02113
deep 1000 m.	19.11	.13963	.5529	.02011	.06675	.02136
N. of Semisopochnoi I. (surface)	18.43	0.13957	0.5587	0.02082	0.06580	0.02183
S. of Amatignak I.	18.04	0.14010	0.5570	0.02171	0.06623	0.02181
North Pacific Area						
surface	18.41	0.14048	0.5572	0.02055	0.06687	0.02172
temp. min. 100 m.	18.45	.13918	.5512	.02174	.06648	.02135
deep 1000 m.	19.17	.13937	—	—	.06632	.02171
Average	18.56	0.13968	0.5553	0.02096	0.06632	0.02154
Kuroshio Region						
Average 33° 50'N 139° 45'E	19.32	0.13993	0.5561	0.02125	0.06627	0.02128
Rejection limit (level of sign. = 0.05)		±0.00147	±0.0081	±0.00125	±0.00113	±0.00052

In Table IV are included also the averaged values for the Kuroshio region calculated from the results of the analyses carried out six times by the present authors. On the basis of the six values, rejection limits were computed for each component. Regarding the limits as a measure, no significant difference is found between the samples collected from the Aleutian region. However, systematic deviations from averaged values are noticed even within the limits. For example, the sulfate as well as sodium in the layer of temperature minimum are lower than each averaged value, both in the Bering Sea area and the Pacific area.

The fact may suggest that a small amount of sodium sulfate has been removed from the sea water by some process. Quantitatively, there is a considerable gap between the equivalents of sulfate and sodium depleted in the sample obtained from the Pacific area, while the equivalents in the Bering Sea area are in the same order, namely 0.44 and 0.66 milli-equivalents for sulfate and sodium, respectively. This may relate to the fact that microcrystals of sodium sulfate are deposited in lattices of ice crystal, upon being removed from sea water, when sea water is frozen in a refrigerator[4].

On the other hand, the tendency of relative increase in sulfate is recognized in the surface layer, suggesting the effect of dilution by melting ice.

Although the mechanism of the change in relative abundance of the dissolved components may be complicated, it may qualitatively be explained as follows. When sea water is cooled from the surface until it forms ice, the sea water should be separated into two phases, namely solid ice phase occluding a smaller amount of salts and a liquid phase containing a concentrated amount of salts. At this time the relative concentration of sodium and sulfate ions in the solid phase may occur. Owing to the concentration of salts in the liquid phase by the separation of the ice phase, the density of the sea water under the ice layer may increase and sink downward by convection process, until the balance of density will be acquired. Thus, the temperature minimum layer having lesser concentration of sodium and sulfate ions may be formed. On the other hand, when the ice is melted, water may have lower density remaining in the surface layer, thus, the relative concentration of sodium and sulfate ions may result.

In Table V the values obtained by the present authors for the Aleutian and Kuroshio regions were compared with those obtained by previous workers for various regions[5].

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[4] G.J. Lewis and T.G. Thompson, *Jour. Mar. Res.*, **9**, 211 (1950); K.H. Nelson and T.G. Thompson, *Jour. Mar. Res.*, **13**, 166 (1954).

[5] T.G. Thompson and R.J. Robinson, "Geophysics of the Earth, V, Oceanography, Chemistry of the Sea" (1932).

TABLE V

AUTHORS' RESULTS COMPARED WITH OTHER DATA OBTAINED BY VARIOUS INVESTIGATORS

Author	Lyman & Fleming (1940)	Thompson & Robinson (1932)	Miyake (1939)	Ratomanov et al. (1936)	Fukai & Shiokawa (1954)	
Location	Average	North Pacific	Kuroshio	Bering Sea	Kuroshio	Aleutian
SO_4	0.1394	0.1396	0.1397	0.1398	0.1399	0.1397
Na	0.5556	0.5495	0.5497	0.5533	0.5561	0.5553
K	0.0200	0.0191	0.0191	0.0187	0.0213	0.0210
Mg	0.06695	0.06694	0.0676	0.0659	0.06627	0.06632
Ca	0.02106	0.02150	0.02155	0.02277	0.02128	0.02154

The values for calcium in the table have been corrected for strontium on the basis of the value determined by Lyman and Fleming⁶⁾, although the strontium determination has not been carried out by the present authors.

Ratomanov mainly referred to Dittmar's values and stated that calcium, sodium and sulfate were higher as shown by the percentage of total salt, while magnesium and potassium were lower in the Bering Sea. However, these characteristics have not been revealed from the results of the present authors' analyses.

The results obtained by the present authors seem to be in close agreement with those obtained by previous authors both in the Aleutian and Kuroshio regions except for the higher potassium values. The cause of these systematic higher values for potassium is not obvious.

Whereas Miyake⁷⁾ pointed out that magnesium in the Kuroshio region was higher, the authors' result shows a rather lower value.

The facts mentioned above may indicate that the mixing of water masses is prevailing in the Aleutian region as a part of the oceanic circulation of the Pacific. Nevertheless, it should be noted that slight deviation from the normal composition may appear.

It has been open to doubt whether the results of freezing experiments of sea water in a laboratory can be applied to the interpretation of natural conditions⁸⁾. As a conclusion, the possibility of change in relative abundance of dissolved components of sea water by natural freezing should be suggested.

Summary

The authors carried out the analyses of the main dissolved components of sea water on the samples collected from the Aleutian region in order to examine the local characteristics of the region under study. At the same time the samples collected from the Kuroshio region were analysed to check the systematic errors introduced. The results were expressed in terms of ratios to chlorinity.

As a result, the following conclusions have been deduced.

1. The relative decrease in sulfate and sodium equivalents was recognized on the samples collected from the layer of temperature minimum. This seems to relate to freezing phenomena of sea water.
2. A tendency of sulfate increase in the surface samples was noticed.
3. Averaged values for the Aleutian region were in close agreement with those for the Kuroshio region, both having been obtained by the present authors. The values also coincided with those obtained by other workers, except for higher potassium values.

These facts may indicate that although the water masses existing in the Aleutian region are, on the whole, a portion of the oceanic circulation of the Pacific, a slight deviation from the normal composition appears in the main components in some characteristic layers.

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6) J. Lyman and R.H. Fleming, *Jour. Mar. Res.*, **3**, 134 (1940).

7) Y. Miyake, This Bulletin, **14**, 29 (1939).

8) H.U. Sverdrup, M.W. Johnson and R.H. Fleming, "The Oceans, their physics, chemistry and general biology", Prentice-Hall, INC., New York, 1952, P. 219.