QUANTITATIVE DISTRIBUTION OF CHEMICAL ELEMENTS IN THE SEA WATER

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Résumé

En étudiant la distribution quantitative des éléments chimiques dans l'eau de mer, M. Ishibashi et ses collaborateurs ont constaté l'existence des relations caractéristiques suivantes :

1. La teneur en éléments appartenant à un même groupe de la classification périodique est d'autant plus faible que le numéro atomique de l'élément considéré est plus élevé, fait que l'on peut mettre en lumière en portant le logarithme de la millimole par litre d'eau de mer en ordonnée et le numéro atomique en abscisse.

2. En portant en ordonnée le logarithme du rapport de la teneur de l'eau de mer en un certain élément à la teneur de la croûte terrestre en ce même élément, et en abscisse le potentiel d'ionisation de cet élément, on obtient une courbe caractéristique qu'il a été décidé d'appeler " courbe de rapport d'existence ".

On the way to systematic research on the elements dissolved in the sea water, Ishibashi and co-workers have found the regularities existing among these elements as follows.

I. Relation between Atomic Number and the Amount of Elements

In the first place, we took only quantities of elements in the sea water for consideration and found a regular relation between the quantities of the elements and their atomic numbers[1]. As shown in Table 1, the quantity of the elements in the same family of the periodic system decreased as the atomic number increases. This rate of decrease gives a straight line in the case of alkali-, alkali earths-, and halogen elements. But by the elements of the first position in the same group, such as lithium, fluorine and beryllium, they show quite exceptional quantities, just as they do in their chemical and physical properties.

Table 1

Elements	Atomic Numbers	g/L	m. m./L	log m. m.
F	9	0. 000822	0. 043	-1. 367 (Carnot)
		0. 0014	0. 74	-0. 131 (Wattenberg)
Cl	17	18. 42	519. 6	2. 71567
Br	35	0. 063	0. 79	-0. 102
I	53	0. 00005	0. 00038	-3. 420
At	85	——	——	——
Li	3	0. 0002	0. 029	-1. 538 (Ishibashi)
Na	11	10. 16	432. 0	2. 635
K	19	0. 37	9. 4	0. 973
Rb	37	$3{\cdot}4\ 10^{-4}$	0. 005	-2. 3 (Ishibashi)
Cs	55	$3{\cdot}4\ 10^{-4}$	$3\ 10^{-5}$	-4. 5 (Ishibashi)
Fr	87	——	——	——
Be	4	$3\ 10^{-8}$	$4\ 10^{-6}$	-5. 4 (Ishibashi)
		$(4\ 10^{-7})$	$(6\ 10^{-5})$	(-4. 3)
Mg	12	1. 24	51. 0	1. 708
Ca	20	0. 40	10. 0	1. 000
Sr	38	0. 013	0. 15	-0. 824
Ba	56	0. 0002	0. 0015	-2. 824
Ra	88	$n\ 10^{-13}$	$n\ 10^{-13}$	-12 -13

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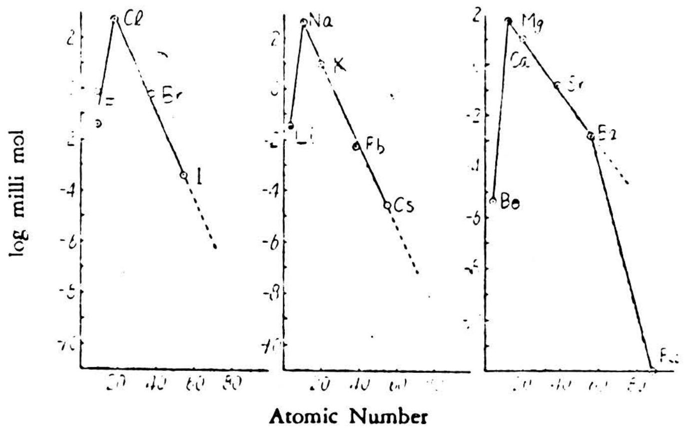
Fig. 1. The regular relation between the quantities of elements and atomic numbers.



As seen in the Fig. 1, we used the quantities proportional to the atomic number, that is, milli mol (m. m.). And we took its common logarithm for ordinate and atomic number for abscissa.

Considering that the quantity of elements dissolved in the sea water is dependent on the degree of facility of their delivery from land by water, it is assumed from a global point of view that the periodical character of chemical and physical property of atom itself would be found, as one of its manifestations between the quantity of the elements in the sea water and their atomic numbers. In dealing with such great source as the ocean, statistical law of great number (Gesetz der grossen Zahlen) would be applied rather satisfactorily. Moreover, in the system of strong uniformity such as the sea water, totality of each individual analysis value is far superior to that of cases on land. This fact, too, is the main cause of regularity recognized by us. Thus considering, in geochemical arguments, its fundamental quantity of the elements should rather be dealt from the standpoint of the quantity rational to their atomic number (m. m.) than from weight percentage.

II. Relation betweent Ionic Potential and the Amount of Elements[2]

Thus in previous case, we have taken only quantities of elements in sea-water into consideration and not those of earth's crust in connection with sea-water. But in this case the latter has also been taken into consideration.

In table 2 the data concerning the elements existing in sea water and in the earth's crust are listed.

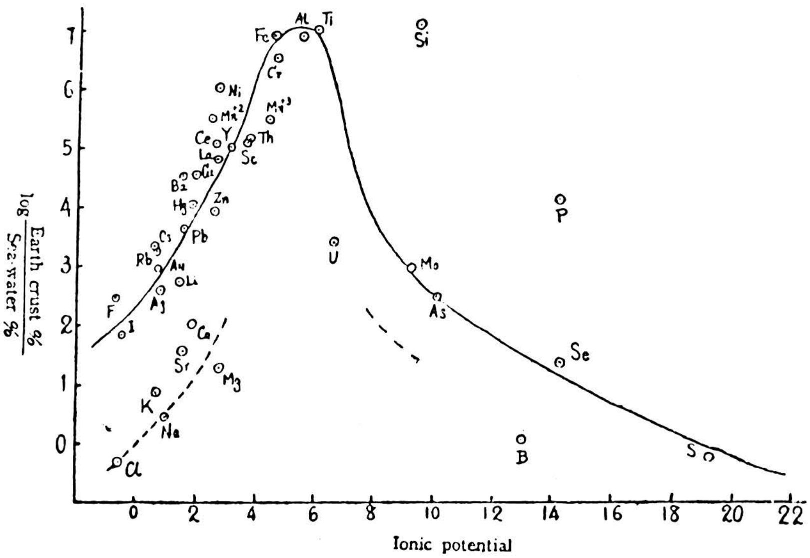
Table 2.

Element	Sea-water γ/L	Earth's Crust %	Element	Sea-water γ/L	Earth's Crust %
Li	120	6×10^{-3}	Ge		6.5×10^{-4}
Be	3×10^{-2}	6×10^{-4}	As	5	5×10^{-4}
B	4.6×10^{3}	1×10^{-3}	Se	4	1×10^{-5}
F	1.4×10^{3}	3×10^{-2}	Br	6.5×10^{4}	6×10^{-4}
Na	1.05×10^{7}	2.63	Rb	200	3×10^{-2}
Mg	1.28×10^{6}	1.96	Sr	1.3×10^{4}	2×10^{-2}
Al	10	7.56	Y	0.3	3×10^{-3}
Si	2×10^{3}	25.8	Zr		2×10^{-2}
P	50	8×10^{-2}	Nb		2×10^{-3}
S	9×10^{5}	6×10^{-2}	Mo	15	1.3×10^{-2}
Cl	1.89×10^{7}	0.19	Tc		1×10^{-7}
K	3.8×10^{5}	2.4	Ru		5×10^{-7}
Ca	4.11×10^{5}	3.39	Rh		1×10^{-7}
Sc	4×10^{-2}	5×10^{-4}	Pd		1×10^{-6}

Table 2. (continued)

Element	Sea-water γ/L	Earth's Crust %	Element	Sea-water γ/L	Earth's Crust %
Ti	0.4	0.46	Ag	0.3	1×10^{-5}
V	1.5×10^{-2}	1.5×10^{-2}	Cd	5×10^{-2}	5×10^{-5}
Cr	6×10^{-2}	2×10^{-2}	In		1×10^{-5}
Mn	3	9×10^{-2}	Sn		4×10^{-3}
Fe	5	4.7	Sb		5×10^{-5}
Co	0.5	4×10^{-3}	Te		2×10^{-7}
Ni	1	1×10^{-2}	I	0.5	3×10^{-5}
Cu	3	1×10^{-2}	Cs	2	7×10^{-4}
Zn	5	4×10^{-3}	Ba	50	2.3×10^{-3}
Ca		1×10^{-3}	La	0.3	1.8×10^{-3}
Ce	0.4	4.5×10^{-3}	W	0.1	6×10^{-3}
Pr		5×10^{-4}	Re		1×10^{-7}
Nd		2.2×10^{-3}	Os		3×10^{-7}
Sm		6×10^{-4}	Ir		1×10^{-7}
Eu		1×10^{-4}	Pt		5×10^{-7}
Cd		6×10^{-4}	Au	4×10^{-4}	5×10^{-7}
Tb		8×10^{-5}	Hg	3×10^{-2}	2×10^{-5}
Dy		4×10^{-4}	Tl		3×10^{-5}
Ho		1×10^{-4}	Pb	4	1.5×10^{-3}
Er		2×10^{-4}	Bi		2×10^{-5}
Tu		2×10^{-5}	Po		4×10^{-4}
Yb		2.5×10^{-4}	Ra	1×10^{-7}	1.4×10^{-10}
Lu		7×10^{-5}	Ac		4×10^{-14}
Hf		4×10^{-4}	Th	0.1	1.2×10^{-3}
Ta		1×10^{-3}	Pa		9×10^{-11}
			U	1.5	4×10^{-4}

Fig. 2. Existing ratio curve.



Setting forth the amount of an element in the sea-water or in the earth's crust with weight percentage, and taking the logarithm of the ratio of two weight percentages to the same element for ordinate and ionic potential for abscissa, we obtain the graph of the relation as shown in Fig. 2. As seen in it, the ratio is presented with a curved line relation against ionic potential. We named it "Existing ratio curve." And it should be taken into consideration that almost the principal elements of sea-water, namely alkali-, alkali earth- and halogen-elements, are deviated from the curve.

As you have seen, another curved line relation shown by the dotted line in Fig. 2, and parallel to the former line, is observed among Cl, Na, K, Mg, U, B, and so on.

Assumption for the Amount of Element in Sea-water

If we assume that the relation shown in Fig. 2 always holds good, the amount of elements dissolved in sea-water as well as yet undetermined amount of some elements are obtained by calculation. And these calculated values are shown in Table 3. Of course there are seen some differences between the quantified values and the calculated ones.

We made use of the data mentioned in table 2 as for the amount of elements in the sea-water and it must be taken into account that to some extent values more or less different are available to us as for the trace elements.

Table 3.

Element	Calculated from the regularity γ/L	Element	Calculated from the regularity γ/L	Element	Calculated from the regularity γ/L
Si	2.9×10^{5}	Al	8	Fe	8.5
Ca	3.5×10^{3}	Na	2.4×10^{4}	K	3.08×10^{4}
Mg	5.64×10^{2}	Ti	0.65	Cl	1.65×10^{4}
Mn^{2}	28.8	P	5.2×10^{4}	S	4×10^{5}
Mn^{3}	0.25	Rb	3.78×10^{2}	Ba	80
F	2.2×10^{3}	Sr	78	Ni	1.5
Cr	0.03	Cu	8(5.6)	Li	19
V^{+4}	0.3	Zn	1.2	Y	0.3
V^{+5}	11	Pb	3.2	Mo	14(13)
Ce	0.8	B	400	Cs	9.8
La	0.3	Sc	0.02	U	0.002
Th	0.04	Hg	0.006	Be	0.0006
As	16	Au	0.006	Be	0.0006
I	2	Co	1	Ga	0.001
Se	7	Nb	0.002	Pd	0.00001
Zr	0.002	Sn	0.004	Sb	0.015
Ge	0.2	Pr	0.16	Nd	0.5
Cd	0.045	Gd	0.06	Dy	0.05
Te	0.009	Hf	0.0005	Ta	0.01
Ra	2.5×10^{-7}	Re	0.01	Os	3×10^{-7}
Lu	0.007	Tl	0.003(0.003)	Bi	0.0003
W	0.4	Eu	0.6	Yb	0.025
Ir	1×10^{-7}	Pt	1×10^{-6}		

Summary

1. Based on the analysis value already quantified by other writers and on that determined by the writers' research, regularity of the relation between the quantity of the elements dissolved in the sea-water and their atomic numbers was found.

2. The relation between the ratio of amount of an element dissolved in sea water of the same element in the earth's crust was considered, and assuming that ionic potential presents, on the whole, the characters of an element, a regularity betwe n the ratio of the amount of an element in sea water to that of the same element in the earths' crust and ionic potential was found. And the amounts of some elements in sea water were calculated from the regularity.