On the Average Chemical Compositions of Some Types of Japanese Effusive Rocks

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Although the bulk chemical composition of an igneous rock is of comparatively little significance in petrogenesis,¹⁾ it may be of some use in petrology. The rocks of a certain region differ as a whole from those of other regions in chemical as well as mineralogical characters.

For characterizing them such statements as that certain oxides in the rocks are high or low, that certain minerals are present in small or large amount, etc., are often given. But to have more definite standards for comparing the rocks of one region with those of others is desirable. In connection with the just-mentioned view the writer calculated the average chemical compositions of some Japanese effusive rock-types, following the method of H.H. Robinson, who formerly established the chemical types of the rocks in the world. The number of the chemical analyses used in the present calculation is 136. These were collected by Mr. Tsuya, to whom the writer thanks heartily for his kindness in offering the data.

1. Type Rhyolite

In the type rhyolite are included the rocks, the silica content of which is 70% or more. The number of chemical analyses taken is 10. The average chemical composition, and the norm and Osann's formula calculated from it are as follows.

1) S. Tsuboi, The Genetical Interpretation of Extrusive Rocks, Jour. Fac. Sci. Imp. Univ. Tokyo, II, Pt. 2, 1925; N. L. Bowen, The Evolution of the Igneous Rocks, 1928, Princeton.

2) H. H. Robinson, The San Franciscan Volcanic Field, U. S. G. S., Prof. Paper 76, 1913, pp. 96-103.

Chemical Wt. %	composition Mol. no.	Norm	Osann's formula
SiO ₂ 73.4	1223	Q 39.62	S 80.86
Al ₂ O ₃ 13.9	136	Or 18.13	A 5.54
Fe ₂ O ₃ 1.4	7	Ab 27.99	C 1.91
FeO 1.0	14	An 7.37	F 2.70
MgO 0.5	12	C 2.70	n 6.19
CaO 1.6	29	Hy 2.17	k 2.04
Na ₂ O 3.0	52	Mt 1.66	
K ₂ O 3.2	32	Il 0.21	
H ₂ O 1.5	—	Ap 0.15	
TiO ₂ 0.1	1	Normative plagioclase Ab ₇₉ An ₂₁	
P ₂ O ₅ 0.2	1		
MnO 0.1	1		
Total 99.9			

2. Type Rhyolite-Andesite

In the type rhyolite-andesite are included the rocks, the silica content of which is 60 % or more but less than 70 %. The number of analyses taken is 40. The average chemical composition, and the norm and Osann's formula calculated from it are as follows.

Chemical Wt. %	composition Mol. no.	Norm	Osann's formula
SiO ₂ 64.6	1076	Q 26.16	S 71.03
Al ₂ O ₃ 16.3	160	Or 10.10	A 4.27
Fe ₂ O ₃ 2.6	16	Ab 25.05	C 6.24
FeO 3.1	43	An 26.66	F 7.95
MgO 1.6	40	Di 0.47	n 7.26
CaO 5.3	95	Hy 7.00	k 1.54
Na ₂ O 2.9	47	Mt 3.75	
K ₂ O 1.7	18	Il 0.61	
H ₂ O 1.3	—	Ap 0.21	
TiO ₂ 0.3	4	Normative plagioclase Ab ₄₅ An ₅₅	
P ₂ O ₅ 0.2	1		
MnO 0.1	1		
Total 100.0			

3. Type Andesite

In the type andesite are included the rocks, the silica content of which is 55 % or more but less than 60 %. The number of analyses taken is 57. The average chemical composition, and the norm and Osann's formula calculated from it are as follows.

Chemical Wt. %	composition Mol. no.	Norm	Osann's formula
SiO ₂ 59.8	998	Q 19.48	S 65.92
Al ₂ O ₃ 17.6	173	Or 8.38	A 3.83
Fe ₂ O ₃ 3.7	23	Ab 22.81	C 7.55
FeO 3.8	53	An 32.11	F 11.58
MgO 2.7	67	Di 2.06	n 7.42
CaO 6.9	124	Hy 9.17	k 1.33
Na ₂ O 2.7	43	Mt 5.36	
K ₂ O 1.4	15	Il 0.31	
H ₂ O 1.2	—	Ap 0.21	
TiO ₂ 0.2	2	Normative plagioclase Ab ₄₂ An ₅₈	
P ₂ O ₅ 0.2	1		
MnO 0.1	1		
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Total 100.3			

4. Type Andesite-Basalt

In the type andesite-basalt are included the rocks, the silica content of which is 50 % or more but less than 55 %. The number of analyses taken is 22. The average chemical composition, and the norm and Osann's formula calculated from it are as follows.

Chemical Wt. %	composition Mol. no.	Norm	Osann's formula
SiO ₂ 52.1	868	Q 9.75	S 57.50
Al ₂ O ₃ 18.3	179	Or 3.31	A 2.69
Fe ₂ O ₃ 3.9	24	Ab 18.32	C 9.03
FeO 7.0	97	An 38.03	F 19.11
MgO 4.5	112	Di 7.66	n 8.51
CaO 9.8	175	Hy 15.85	k 1.07

Chemical		composition	Norm
Wt. %		Mol. no.	
Na ₂ O	2.2	35	Mt 5.53
K ₂ O	0.6	6	Il 1.35
H ₂ O	1.2	—	Ap 0.20
TiO ₂	0.5	9	Normative plagioclase Ab ₃₄ An ₆₆
P ₂ O ₅	0.1	1	
MnO	0.1	1	
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Total	100.3		

5. Type Basalt

In the type basalt are included the rocks, the silica content of which is less than 50 %. The number of analyses taken is 7. The average chemical composition, and the norm and Osann's formula calculated from it are as follows.

Chemical		composition	Norm	Osann's formula
Wt. %		Mol. no.		
SiO ₂	47.4	789	Q 7.17	S 52.21
Al ₂ O ₃	18.6	183	Or 2.18	A 2.17
Fe ₂ O ₃	6.6	41	Ab 14.87	C 9.89
FeO	5.5	76	An 40.51	F 23.65
MgO	5.3	133	Di 13.95	n 8.80
CaO	12.2	217	Hy 11.74	k 0.92
Na ₂ O	1.8	29	Mt 9.23	
K ₂ O	0.4	4	Il 0.23	
H ₂ O	2.0	—	Ap 0.20	
TiO ₂	0.2	2	Normative plagioclase Ab ₂₇ An ₇₃	
P ₂ O ₅	0.1	1		
MnO	0.1	1		
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Total	100.2			

By plotting the above cited five rock-types on rectangular coordinates are obtained the diagrams of Figure 1, in which the abscissae represent the content of silica in molecular numbers and the ordinates that of other chief oxides. Table I shows the molecular numbers of the chief oxides obtained from the graphs

of Figure 1 by the method of interpolation and extrapolation.

In Fig. 2, is shown the relation between the value of k in Osann's formula and the composition of the normative plagioclase for each rock-type. As may be seen from this figure the composition of normative plagioclase for the rock in which $k=1$ is $Ab_{31}An_{69}$.

Lastly, the ratios of Na_2O to K_2O , and of Al_2O_3 to $CaO + Na_2O + K_2O$ are graphically shown in Figs. 3 and 4 respectively.

Table I. The Molecular Numbers of the Chief Oxides						
SiO_2	Al_2O_3	Fe_2O_3 and FeO	MgO	CaO	Na_2O	K_2O
750	181	177	148	238	25	2
800	182	156	131	209	28	4
850	180	148	115	185	32	6
900	178	132	98	163	36	8
950	176	116	83	145	39	12
1000	172	100	66	124	43	15
1050	167	83	50	103	46	18
1100	158	68	35	83	48	21
1150	150	51	25	60	50	25
1200	140	35	16	41	51	30
1250	128	20	7	20	53	36

Fig. 1

Fig. 2

Fig. 3

Fig. 4