23. The Measurement of the Viscosity of Basalt Glass at High Temperatures, II.

By Kôichi KANI.

Electro-technical Laboratory, Ministry of Communications, Tokyo.

(Comm. by S. KôZU, M.I.A., Feb. 12, 1934.)

The viscosity of basalt glass:—The chemical compositions of basalts used for the present experiments are given in Table IV and their localities are as follows:—

1. Olivine basalt from Gembudô, Tazima Prov., Japan.
2. Olivine basalt from Kônoura, Shôdo-shima, Sanuki Prov., Japan.
3. Andesitic basalt from Motomura, Ô-shima, Izu, Japan.
4. Nepheline basalt from Nagahama, Iwami Prov., Japan.

TABLE IV.

	Olivine-basalt, Gembudô	Olivine-basalt, Kônoura	Andesitic basalt, Motomura	Nepheline- basalt, Nagahama
SiO ₂	49.29	49.24	51.80	35.66
Al ₂ O ₃	18.49	16.81	15.00	11.97
Fe ₂ O ₃	2.38	6.16	3.68	5.19
FeO	6.77	3.60	10.14	9.69
MgO	6.09	8.02	5.36	8.35
CaO	8.14	9.49	9.77	14.39
Na ₂ O	3.93	2.67	1.76	3.65
K ₂ O	1.79	1.09	0.32	1.89
H ₂ O	0.88	1.50	0.62	4.04
TiO ₂	2.22	1.33	0.60	3.74
P ₂ O ₅	Tr.	0.43	0.31	1.37
MnO	0.22	0.17	0.20	0.30
Total	100.20	100.51	100.56	100.24

Using the apparatus¹⁾ stated above, the viscosities of the four different basalt glasses were measured at six different temperatures in the range from 1150°C to 1400°C, the charge being kept at each constant temperature for one hour. The values of k and k' for these four basalt glasses, obtained from W' and S which were observed by the present experiments (Table V), are given in Table VI. The final results, which were obtained by calculation by the use of k and the two constants given in the formula (2),²⁾ are shown in Table VII, and the relation between the viscosity and temperature in these basalt glasses is shown in Figs. 4 and 5.

From Table VII and Figs. 4 and 5, it is seen that the viscosity of the nepheline

Fig. 4.

1) Proc. **10** (1934), 29.

2) Proc. **10** (1934), 32.

basalt is considerably less than that of common basalt, and the rapid increase of the viscosity in small range of temperature from 1250°C to 1200°C in these basalt glasses is clearly due to the rapid increase of crystallizing minerals of magnetite and plagioclase.

The results of the microscopic observations made for thin sections of the Genbudô basalt glass, heated at desired temperatures for one hour and then quenched, are shown in Table VIII. The magnetite crystal begins to crystallize at $1308^{\circ}\pm 3^{\circ}\text{C}$ and increases in quantity on the fall of temperature. At $1253^{\circ}\pm 3^{\circ}\text{C}$, the plagioclase appears to crystallize in addition to magnetite and at about 1200°C its quantity increases rapidly. These observations can explain well the change in the trend of the viscosity curve of the glass.

It is of course obvious that we cannot directly compare the viscosity of the fused basalt with that of the corresponding basalt magma which contains an abundant quantity of volatile components. However, we can say that the viscosity of the basalt magma cannot exceed that of the fused basalt under the same condition.

According to R. F. Proctor and R. W. Douglas, the viscosities ($\log \eta$) of the commercial soda glasses, whose chemical compositions vary in the range of $\text{SiO}_2=71.4\text{--}73.2$, $\text{Na}_2\text{O}=19.4\text{--}20.8$, $\text{CaO}=6.3\text{--}7.1$, $\text{MgO}=0.2\text{--}0.5$, $\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3=0.8\text{--}1.2$, are approximately 2.25–2.40 at 1300°C and 2.5 at 1250°C , while the viscosities of the fused basalts, with the exception of the nepheline basalt glass, are 2.24–2.47 at 1300°C and 2.53–2.82 at 1250°C . So we see that in the neighbourhood of these temperatures, the viscosities of the fused basalts are slightly higher than those of soda glasses.

In conclusion, the author would like to offer his hearty thanks to Prof. S. Kôzu of Tohoku Imperial University for his kind guidance and encouragement extended through this investigation and he also wishes to express his cordial gratitude to Dr. Y. Ogawa, chief engineer of the Fifth Section of this Electric Laboratory, under whose direction

Fig. 5.

the present study was performed. The author is much indebted to Mr. K. Hosokawa in our laboratory for his enthusiastic assistance in a part of the experiment.

TABLE V.
Number (S) of revolution per minute at different temperatures and loads.

	Load in grammes (W)	1400° C	1350° C	1300° C	1250° C	1200° C	1150° C
Gembudó, basalt-glass	2.5	12.45	—	—	—	—	—
	3	17.65	11.36	6.98	—	—	—
	4	25.00	18.63	12.25	6.14	—	—
	5	34.88	26.09	—	—	—	—
	6	—	32.26	22.06	11.77	—	—
	8	—	—	29.70	16.67	—	—
	10	—	—	—	22.22	6.35	—
	12	—	—	—	—	8.02	—
	16	—	—	—	—	11.32	—
	20	—	—	—	—	14.22	—
	30	—	—	—	—	—	2.95
	40	—	—	—	—	—	3.54
	50	—	—	—	—	—	4.67
	60	—	—	—	—	—	6.74
Kónoura, basalt-glass	2.5	15.40	13.64	—	—	—	—
	3	21.43	18.81	13.07	7.50	—	—
	4	30.00	26.79	20.13	12.00	—	—
	5	40.00	34.48	28.30	—	—	—
	6	—	—	33.64	—	11.15	—
	8	—	—	—	29.27	15.00	could not measured by rapid increase of viscosity
	10	—	—	—	37.98	20.27	
	12	—	—	—	—	25.21	
Motomura, basalt-glass	2.5	13.06	—	—	—	—	—
	3	18.75	12.71	7.44	—	—	—
	4	26.10	18.75	13.64	7.49	—	—
	5	35.30	25.64	—	—	—	—
	6	—	33.33	24.24	13.33	—	—
	8	—	—	33.80	20.00	—	—
	10	—	—	—	25.00	—	—
	16	—	—	—	—	2.00	—
	20	—	—	—	—	2.48	—
	25	—	—	—	—	3.11	—
	30	—	—	—	—	3.85	1.21
	35	—	—	—	—	4.76	—
	40	—	—	—	—	—	1.68
	50	—	—	—	—	—	2.42
	60	—	—	—	—	—	3.27
Nagahama, neph.- basalt-glass	2	15.39	—	—	—	—	—
	2.5	24.19	20.55	18.92	15.39	—	—
	3	30.00	27.27	25.00	20.69	13.45	—
	3.5	34.88	—	—	—	—	—
	4	—	37.50	34.29	30.30	21.73	—
	4.5	—	46.15	48.39	39.41	—	could not measured by rapid increase of viscosity
	5	—	—	—	—	27.03	
	6	—	—	—	—	34.88	

TABLE VI.

k and k' of the four different basalt glasses at different temperatures in the equation $W=kS+k'$.

Temp. in °C	Olivine basalt, Gembudô		Olivine basalt, Kônoura		Andesitic basalt, Motomura		Nepheline basalt, Nagahama	
	k	k'	k	k'	k	k'	k	k'
1400	0.1167	1.0056	0.1056	0.8060	0.1179	0.8846	0.0791	0.6849
1350	0.1411	1.3856	0.1165	0.8099	0.1454	1.2128	0.0838	0.7470
1300	0.2151	1.4328	0.1392	1.1896	0.1890	1.5141	0.0903	0.7666
1250	0.3812	1.5879	0.2304	1.2540	0.3298	1.5803	0.1039	0.8331
1200	1.2544	1.9990	0.4139	1.5890	7.0218	2.5650	0.1496	0.8678
1150	8.1350	8.5970	—	—	14.2550	14.9440	—	—

TABLE VII.

Temp. in °C	Olivine basalt, Gembudô		Olivine basalt, Kônoura		Andesitic basalt, Motomura		Nepheline basalt, Nagahama	
	η'	$\log \eta'$	η'	$\log \eta'$	η'	$\log \eta'$	η'	$\log \eta'$
1400	136.68	2.1357	119.73	2.0782	138.55	2.1416	79.76	1.9018
1350	175.83	2.2451	136.37	2.1348	182.94	2.2623	88.11	1.9450
1300	296.15	2.4715	172.67	2.2372	259.12	2.4135	97.34	1.9883
1250	656.15	2.8170	336.59	2.5271	541.51	2.7336	117.14	2.0687
1200	3180.60	3.5025	731.82	2.8644	31168.00	4.4937	190.00	2.2789
1150	37897.00	4.5786	Rapid increase	—	79470.00	4.9002	Rapid increase	—

TABLE VIII.

Temp. in °C	Time in hrs.	Result	Temp. in °C	Time in hrs.	Result
1340	1	glass	1255	1	"
1330	1	"	1250	1.5	glass + magnetite + plagioclase.
1320	1	"	1245	1.5	"
1310	1	"	1240	1.5	"
1305	1	glass + magnetite	1230	1.5	"
1300	1	"	1225	1.5	"
1295	1	"	1200	2	The amount of crystal increases rapidly.
1290	1	"	1187	2	"
1285	1	"	1175	2	"
1280	1	"	1163	2	glass + plagioclase + hematite (?).
1275	1	"	1150	2.5	"
1270	1	"			
1265	1	"			
1260	1	"			