112. Viscosity Phenomena of the System KAlSi₃O₈–NaAlSi₃O₈ and of Perthite at High Temperatures.

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Using the same instrument with which the viscosities of basalt glasses¹ were previously determined by the author, the same property of the binary system KAlSi₃O₈–NaAlSi₃O₈ and also that of a natural perthite, whose locality is Ishikawa, Prefecture Fukushima, were measured under the same condition.

The instrument is a cylinder-rotation type, as already described in these Proceedings,² and the viscosity of the material under examination can be obtained by the calculation of the equation

\[ \log \gamma' = 1.3252 \log k \cdot 10^2 + 0.7217, \]

in which \( \gamma' \) is the viscosity and \( k \) is equal to \( (W' - k')/S \). \( W' \) and \( S \) are the load in grammes and the revolution per minute, both being experimentally obtained in using this apparatus.

Six different chemical compositions of the charges belonging to the binary system KAlSi₃O₈–NaAlSi₃O₈ were taken for the present experiment, they are KAlSi₃O₈(Or), NaAlSi₃O₈(Ab), 80 wt % of Or and 20 wt % of Ab, 60 wt % of Or and 40 wt % of Ab, 40 wt % of Or and 60 wt % of Ab, and 20 wt % of Or and 80 wt % of Ab.

For the formation of these glasses, SiO₂ was obtained from transparent quartz, whose fine powder was purified by HCl, and Al₂O₃, K₂CO₃ and Na₂CO₃ were those prepared by Kahlbaum Co. The refractive indices of these glasses for sodium ray, determined by a total reflectometer, are as seen in Table I.

Comparing the refractive indices of Or- and Ab-glasses formed in this case with those (1.485 for Or-glass and 1.489 for Ab-glass) of the same compositions determined by Morey and Bowen, we see that our results are slightly higher than the other's, though the differences do not exceed 0.0015. It is evident that these differences must depend upon the variation of the chemical compositions of these charges. A trial of chemical analysis was made for Or-glass and it was seen that the rather larger differences are in K₂O and Al₂O₃, that is, in the Or-glass made in this case, K₂O is 0.20% less than the theoretical composition of Or and while in the same glass Al₂O₃ is

<table>
<thead>
<tr>
<th>Composition in wt %</th>
<th>Ref. index</th>
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</thead>
<tbody>
<tr>
<td>100% Or</td>
<td>1.4865</td>
</tr>
<tr>
<td>80% Or, 20% Ab</td>
<td>1.4874</td>
</tr>
<tr>
<td>60% Or, 40% Ab</td>
<td>1.4886</td>
</tr>
<tr>
<td>40% Or, 60% Ab</td>
<td>1.4886</td>
</tr>
<tr>
<td>20% Or, 80% Ab</td>
<td>1.4898</td>
</tr>
<tr>
<td>100% Ab</td>
<td>1.4902</td>
</tr>
</tbody>
</table>

¹) Proc. 10 (1934), 79–82.
²) Proc. 10 (1934), 29–32.
0.33% greater than in the latter. These differences must cause the increasing of the refractive index in the glass in some extent.

The results of the experiment:—The values of W' and S were experimentally obtained by this cylinder-rotation method and those of k and k' were obtained by the calculation of the equation \( W' = kS + k' \) for different temperatures between 1450°C and 1300°C. The logarithms of the viscosities which are obtainable by the calculation of the equation (1) are given in Table II. The change in \( \log \gamma' \) referred to the temperatures applied in this experiment is shown in Fig. 1 and the change in \( \log \gamma' \) referred to the chemical compositions in the binary system KAlSi₃O₈–NaAlSi₃O₈ is seen in Fig. 2. We see from Fig. 1 that the change in \( \log \gamma' \) of each charge can be expressed by a straight line in the range of the applied temperatures and these straight lines for a series of different compositions in the binary system are practically parallel to each other. For a constant temperature, the change in \( \log \gamma' \) referred to the composition can be indicated by a more complicated curve as is seen in Fig. 2 and the inclination of its trend is

<table>
<thead>
<tr>
<th>Temp. in °C</th>
<th>100% Or</th>
<th>80% Or, 20% Ab</th>
<th>60% Or, 40% Ab</th>
<th>40% Or, 60% Ab</th>
<th>20% Or, 80% Ab</th>
<th>100% Ab</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \log \gamma' )</td>
<td>( \log \gamma' )</td>
<td>( \log \gamma' )</td>
<td>( \log \gamma' )</td>
<td>( \log \gamma' )</td>
<td>( \log \gamma' )</td>
</tr>
<tr>
<td>1450</td>
<td>6.6025</td>
<td>5.8454</td>
<td>5.5067</td>
<td>5.3989</td>
<td>5.2519</td>
<td>—</td>
</tr>
<tr>
<td>1425</td>
<td>6.7448</td>
<td>6.0196</td>
<td>5.6715</td>
<td>5.6308</td>
<td>5.4289</td>
<td>5.0572</td>
</tr>
<tr>
<td>1400</td>
<td>7.0094</td>
<td>6.2264</td>
<td>5.8826</td>
<td>5.8046</td>
<td>5.6576</td>
<td>5.2493</td>
</tr>
<tr>
<td>1375</td>
<td>—</td>
<td>6.4694</td>
<td>6.0663</td>
<td>6.0225</td>
<td>5.8391</td>
<td>5.4525</td>
</tr>
<tr>
<td>1350</td>
<td>—</td>
<td>—</td>
<td>6.3022</td>
<td>6.1790</td>
<td>6.0225</td>
<td>5.6381</td>
</tr>
<tr>
<td>1325</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>6.2196</td>
<td>5.8539</td>
</tr>
<tr>
<td>1300</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>6.0400</td>
</tr>
</tbody>
</table>
most gentle in the range of concentration from 30% to 70% of Ab and is most steep for the concentration between 80% and 100% of Or.

The viscosity of perthite:—The viscosities of perthite for four different temperatures were measured as before and the results are:

<table>
<thead>
<tr>
<th>Temp. in °C</th>
<th>1450</th>
<th>1425</th>
<th>1400</th>
<th>1375</th>
</tr>
</thead>
<tbody>
<tr>
<td>log (\eta')</td>
<td>6.0775</td>
<td>6.3022</td>
<td>6.5794</td>
<td>6.8089</td>
</tr>
</tbody>
</table>

These results are also plotted in Fig. 1 to compare with those of the artificial glasses. From the figure, we see that the viscosity of perthite is higher than that which we have expected from its chemical composition previously analyzed by K. Seto in our Institute, its molecular formula being given as \(\text{Or}_{38.8}\text{Ab}_{31.7}\text{An}_{25}\). The refractive index of the perthite glass is 1.4875 and that of the artificial glass of 80% of Or and 20% of Ab is 1.4874. If we take only this optical property in comparing their viscosities, the results obtained by the present measurements for these two glasses may be considered as showing an agreement of a satisfactory order, that is, log \(\eta'\) in the range of temperatures from 1375°C to 1450°C varies in the limits of about 5.8 and 6.8.

In conclusion, the author would like to offer his hearty thanks to Prof. S. Kōzu of Tohoku Imperial University for his kind guidance and encouragement extended through this investigation. He is also much indebted to Mr. K. Hosokawa in our laboratory for his enthusiastic assistance in a part of this experiment.