DIAPLECTIC GLASS AND FUSION-FORMED GLASS: COMPARATIVE STUDIES ON SHOCKED ANORTHOSITE FROM MANICOUAGAN CRATER, CANADA.

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The aim of the present study was the systematic elucidation of differences in thermal behavior and crystallization characteristics between diaplectic glass and its "normal" fusion-formed glassy analogue. Such a comparative study might possibly provide informations on the structure of diaplectic glasses. Shocked anorthosite from the Manicouagan crater has been chosen which consists of about 90% plagioclase (An52-An58) transformed to a considerable degree into diaplectic glass (1). Glass prepared by laboratory fusion of this anorthosite and a synthetic An55 plagioclase glass have been used as fusion-formed analogues. Relevant data of the three sample materials are given in Table 1.

Thermal expansion measurements (2) revealed that the diaplectic anorthosite glass exhibits distinctly the phenomenon of the glass transition with a very large increase in expansion coefficient just above Tg. In contrast, the glass transition is barely visible in the expansion curves of the fusion-formed analogues (Table 1). As thermal expansion just above Tg appears to be directly related to the amount of nonbridging oxygen in the structure (3), these results seem to indicate that the diaplectic glass contains a considerable amount of nonbridging oxygen whereas the fusion-formed analogues are essentially devoid of this network defect. However, the average values of Tg are essentially the same for both types of glasses (Table 1).

Measurements of viscosity, η, (2) showed that the diaplectic anorthosite glass exhibits low-temperature viscous flow above Tg; however, the log η versus 1/T relation is steeper for the diaplectic glass than for the synthetic An55 fusion glass. At η < 10^10 poise the fluidity (1/η) of the diaplectic glass is much higher than that of the fusion glass which again indicates a considerable amount of nonbridging oxygen in the former (3).

The diaplectic anorthosite glass differs also in crystallization behavior from its fusion-formed analogues. The latter showed appreciable crystallization only at temperatures above about 900 °C and crystallization proceeded by the advance of a crystalline front with fibrillar morphology from the surface into the interior of the glass samples - the typical crystallization behavior of fusion-formed plagioclase glasses (4). The linear rates of crystal growth obtained on the present fused glasses are shown as functions of temperature in Fig. 1 together with growth rates reported for other plagioclase glasses (4). It should be noted that all growth rates in Fig. 1 are independent of time at constant temperature. The maximum growth rates were observed at 1260 and 1300 °C on the fused anorthosite glass and the synthetic An55 glass, respectively.

In contrast, crystallization in the diaplectic anorthosite glass becomes noticeable at temperatures as low as 800 °C. Crystallization starts at arbitrary points and forms patches of
Table 1

<table>
<thead>
<tr>
<th>Sample material</th>
<th>( \bar{\rho} ) (g·cm(^{-3}))</th>
<th>( \bar{n}_D )</th>
<th>( T_L ) (°C)</th>
<th>( T_g ) (°C)</th>
<th>( \alpha_{r} ) x10(^{6})°C(^{-1} )</th>
<th>( \alpha_{l} ) x10(^{6})°C(^{-1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diaplectic Manicouagan anorthosite glass</td>
<td>2.576</td>
<td>1.538</td>
<td>-</td>
<td>785±15</td>
<td>5.6±0.5</td>
<td>54±5</td>
</tr>
<tr>
<td>Fused diaplectic Manicouagan anorthosite glass</td>
<td>2.552</td>
<td>1.537</td>
<td>1475±10</td>
<td>785±10</td>
<td>6.1±0.5</td>
<td>8.5±0.5</td>
</tr>
<tr>
<td>Synthetic An55 glass</td>
<td>2.549</td>
<td>1.536</td>
<td>1475±10</td>
<td>780±10</td>
<td>5.9±0.5</td>
<td>5.9±0.5</td>
</tr>
</tbody>
</table>

Fig. 1
Variation of linear rate of crystal growth with temperature for various fusion-formed plagioclase glasses. Broken lines represent data of this study, solid lines represent reported data (4).

Fig. 2
Fraction crystallized in diaplectic glass samples in wt.% after different annealing times at various temperatures.
crystalline areas which, at sufficiently high temperatures, spread out until the total sample is crystallized. The individual crystalline areas, which are generally of macroscopic size, are apparently single-crystals. They display conoscopic biaxial positive interference figures, i.e. the optic character of unshocked plagioclase of intermediate An content. This suggests that on crystallization the primary mineral grains with a structure similar to the original one are restored. This suggestion which is in accordance with the conclusion of previous authors (5) is supported by the mutual different orientations of the crystallized areas. However, as indicated by their wavy extinction, the structure of the recrystallized grains is distorted to some extent.

The fractions crystallized in diaplectic anorthosite glass samples after different annealing times at various temperatures were determined by quantitative infrared spectroscopic analysis and are shown in Fig. 1. It is apparent that crystallization increases initially rapidly with time, but decreases soon significantly and approaches even saturation values. There also appears to exist a peculiarity in crystallization on annealing between 10 and 60 min at 800 ºC. As this temperature is close to the Tg of the diaplectic glass, this phenomenon may possibly be related with the glass transition process.

It is obvious that the crystallization behavior of the diaplectic anorthosite glass is different from that of its fusion-formed analogues. This again is an indication that the two types of amorphous solids are structurally different. The above observations suggest that the structure of the diaplectic anorthosite glass is rather closely related to the structure of the unshocked primary plagioclase mineral, and that its amorphous nature is mainly due to a high concentration of lattice defects, especially nonbridging oxygen.

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Literature