

Glass

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[Reprinted from the Journal of The American Ceramic Society, Vol. 45, No. 8, August, 1962.]

Reply to "Comments on 'Effects of Ultrahigh Pressures on Glass'"

by H. M. COHEN and RUSTUM ROY

WEIR and Spinner¹ recently made several comments on a note by Cohen and Roy.² Since it is felt that these comments may lead to a degree of confusion concerning the nature and meaning of the data reported by Cohen and Roy, a rebuttal is in order.

Weir and Spinner state that since Bridgman and Simon³ present their results in terms of density changes, whereas Cohen and Roy present their results in terms of changes in index of refraction, a reader cannot directly compare the two sets of data until the relation between index and density has been experimentally established.

The note by Cohen and Roy clearly states (p. 523) that, on the basis of *observed* densities and refractive indices, there was a difference of only 3.5% between the respective molar refractions of the normal silica glass ($n = 1.458$) and the most dense silica glass ($n = 1.54$). Thus, the index of refraction is related to the density through the Lorentz-Lorenz equation. Although densities were measured, only the refractive indices (the more easily measured parameter) were presented because of the space limitations of the note.

The refractive index versus density plot for silica glass and a few other silicate glasses is presented in Fig. 1 to show the values of density measured and the nature of the relation between these two parameters for progressively densified silicate glasses.

Weir and Spinner also remark that the discrepancy between the results of Bridgman and Simon³ and Cohen and Roy² may arise because of the relative degree to which the respective results were "... affected by plastic deformation arising from the nonhydrostatic pressures ..."

There is absolutely no doubt that shear has a very pronounced effect on the rate at which the glass samples respond to the pressure-temperature environment. However, Dacheille and Roy⁴ have shown that shear, although it changes the kinetics of a structural transformation, *does not change the equilibrium* relations within their experimental error. The fact that shear plays an important role in the *kinetics* of densification in no way detracts from the validity of conclusions based on the observed pressure-induced compaction in glass. Further, the reference listed under footnote 2 in the note by Cohen and Roy² states explicitly that points falling on the same curve were obtained from samples sealed in capsules and exposed to argon pressure up to 10 kilobars.

Weir and Spinner also state that the results of Cohen and Roy are "... in interesting contrast with those of Anderson,⁵ who compressed a borosilicate glass using a different experimental technique." Although the difference in experimental technique and glass composition was pointed out, it was not mentioned that the magnitude of the pressure-temperature range in Anderson's study (6.6 kilobars, 285°C) was far different from the magnitude of the pressure-temperature range used in the study by Cohen and Roy (200 kilobars, up to 600°C), and Anderson made no effort to determine whether his glass was at equilibrium with the pressure-temperature environment.

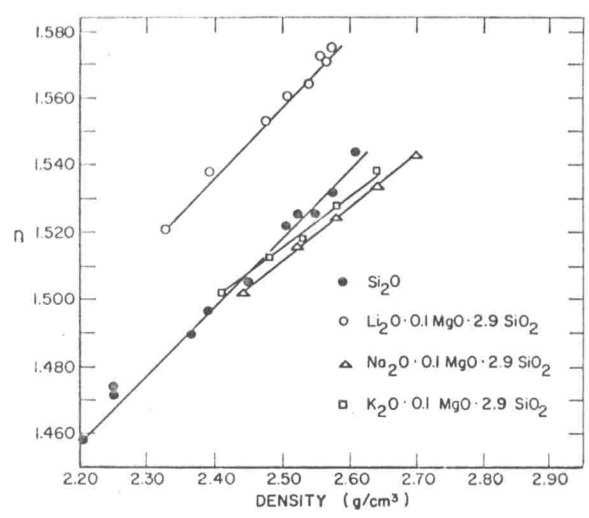


Fig. 1. The refractive indices refer to the sodium D line for silica glass and to white radiation for the other glasses. Each point represents an uncertainty of ± 0.005 index of refraction units and ± 0.01 g per cm^3 density units. Compositions are expressed as molar ratios.

Further, Anderson's samples were exposed to gas pressure. It is quite possible that the small "reversible" density changes observed by Anderson ($\sim 8 \times 10^{-4}$ g per cm^3) could arise from solution of the gaseous pressure-transmitting medium into the glass (Henry's law). The question of the equilibrium solubility of gas

Received May 28, 1962.

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¹ C. E. Weir and S. Spinner, "Comments on 'Effects of Ultrahigh Pressures on Glass,'" *J. Am. Ceram. Soc.*, **45** [4] 196 (1962).

² H. M. Cohen and Rustum Roy, "Effects of Ultrahigh Pressures on Glass," *J. Am. Ceram. Soc.*, **44** [10] 523-24 (1961).

³ P. W. Bridgman and I. Simon, "Effect of Very High Pressures on Glass," *J. Appl. Phys.*, **24** [4] 405-13 (1953); *Ceram. Abstr.*, **1953**, September, p. 168g.

⁴ F. Dacheille and R. Roy, "Influence of 'Displacive-Shearing' Stresses on Kinetics of Reconstructive Transformations Effected by Pressure in the Range 0-100,000 Bars"; pp. 502-11 in *Reactivity of Solids—Proceedings of 4th Symposium*, Amsterdam, 1960. Edited by J. H. de Boer, W. G. Burgers, E. W. Gorter, J. P. F. Huesse, and G. C. A. Schuit. Elsevier Publishing Co., Princeton, N. J., 1961. 762 pp.; *Ceram. Abstr.*, **1962**, May, p. 131a.

⁵ O. L. Anderson, "Effect of Pressure on Glass Structure," *J. Appl. Phys.*, **27** [8] 943-49 (1956); *Ceram. Abstr.*, **1957**, January, p. 6c.