Table 5.2.3

Corning 9658 GC: Elastic Properties and their Polynomial Coefficients

Density = 2,553 g/cc v_ℓ = 5,446 km/s v_t = 3,178 km/s

ELASTIC CONSTANT	TEMPERATURE (°C)	COEFFICIENTS OF EQUATION $M = a_0 + a_1P + a_2P^2 + a_3P^3$				$X \leq P \leq Y$ (GPa)	
		a_0	a_1 (GPa^{-1})	a_2 (GPa^{-2})	a_3 (GPa^{-3})	X	Y
C_{11} (GPa)	19	76,11	9,08	-1,85	0,02	0,76	3
	104	78,09	7,03	-1,89	3,15 X 10^{-1}	0,63	3
	151	77,48	5,99	-0,57	3,74 X 10^{-2}	1,14	3
	229	77,36	7,45	-1,24	1,54 X 10^{-1}	1,39	3
C_{44} (GPa)	19	25,97	3,50	-0,82	7,82 X 10^{-2}	0,76	3
	104	24,72	4,23	-1,44	2,09 X 10^{-1}	0,63	3
	151	25,39	2,41	-0,41	3,76 X 10^{-2}	1,14	3
	229	25,46	2,09	-0,31	5,26 X 10^{-2}	1,39	3
E (GPa)	19	64,46	8,35	-1,87	1,85 X 10^{-1}	0,76	3
	104	62,75	9,2	-3,01	4,46 X 10^{-1}	0,63	3
	151	63,79	5,71	-0,86	7,54 X 10^{-2}	1,14	3
	229	64,90	4,04	-0,17	2,90 X 10^{-2}	1,14	3
B (GPa)	19	41,48	4,42	-0,76	9,60 X 10^{-2}	0,76	3
	104	45,13	1,39	2,95 X 10^{-2}	3,65 X 10^{-2}	0,63	3
	151	43,63	2,78	-0,24 X 10^{-1}	-0,13 X 10^{-1}	1,14	3
	229	43,42	4,66	-0,83	8,38 X 10^{-2}	1,39	3
C_{12} (GPa)	19	24,17	2,09	-0,22	4,39 X 10^{-2}	0,76	3
	104	28,66	-1,43	9,91 X 10^{-1}	-0,10	0,63	3
	151	26,71	1,18	2,47 X 10^{-1}	-0,38 X 10^{-1}	1,14	3
	229	26,45	3,27	-0,63	4,87 X 10^{-2}	1,39	3
σ	19	2,41 X 10^{-1}	-0,55 X 10^{-2}	2,75 X 10^{-3}	-0,21 X 10^{-3}	0,76	3
	104	2,68 X 10^{-1}	-0,26 X 10^{-1}	1,13 X 10^{-2}	-0,15 X 10^{-2}	0,63	3
	151	2,50 X 10^{-1}	3,43 X 10^{-3}	-0,15 X 10^{-2}	3,32 X 10^{-4}	1,01	3
	229	2,55 X 10^{-1}	4,43 X 10^{-3}	-0,14 X 10^{-2}	7,27 X 10^{-6}	1,39	3
V/V_0	19	9,999 X 10^{-1}	-0,23 X 10^{-1}	8,04 X 10^{-4}		0,5	3
	104	1,0	-0,22 X 10^{-1}	5,96 X 10^{-4}		0,5	3
	151	9,997 X 10^{-1}	-0,23 X 10^{-1}	7,69 X 10^{-4}		0,5	3
	229	1,0	-0,22 X 10^{-1}	6,52 X 10^{-4}		0,5	3

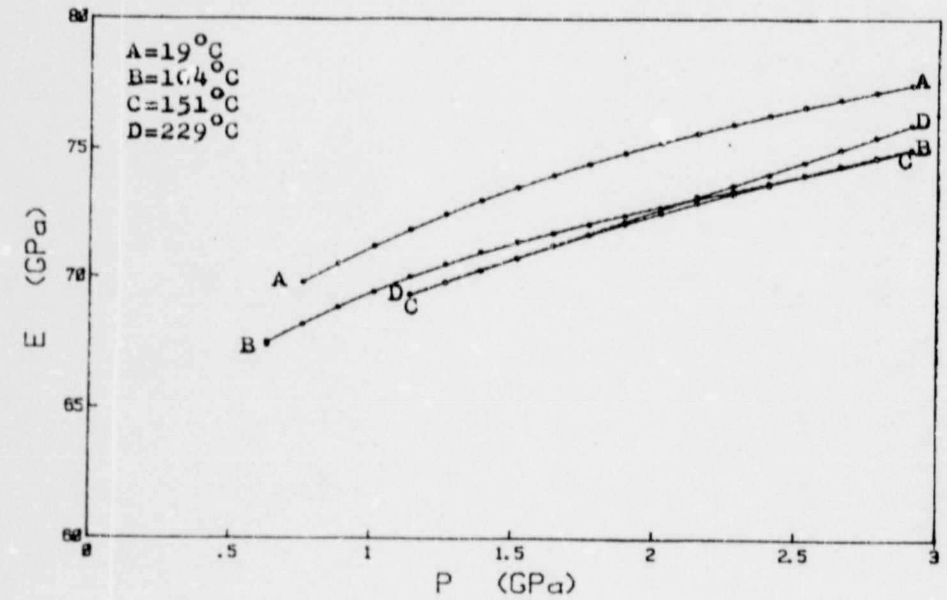

Fig. 5.2.8 9658 GC: Young's modulus vs pressure

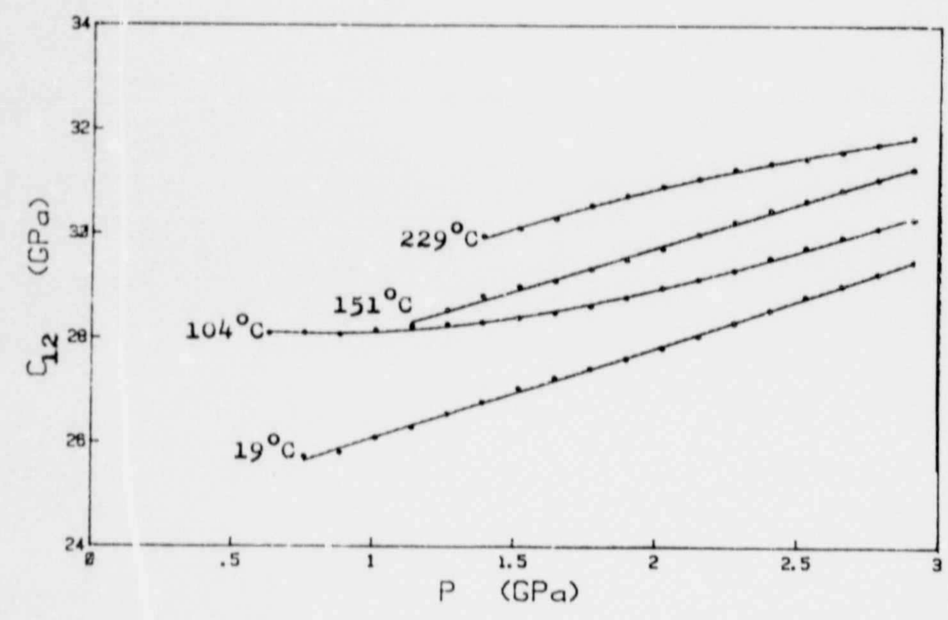

Fig 5.2.9 9658 GC: Lamé constant vs pressure

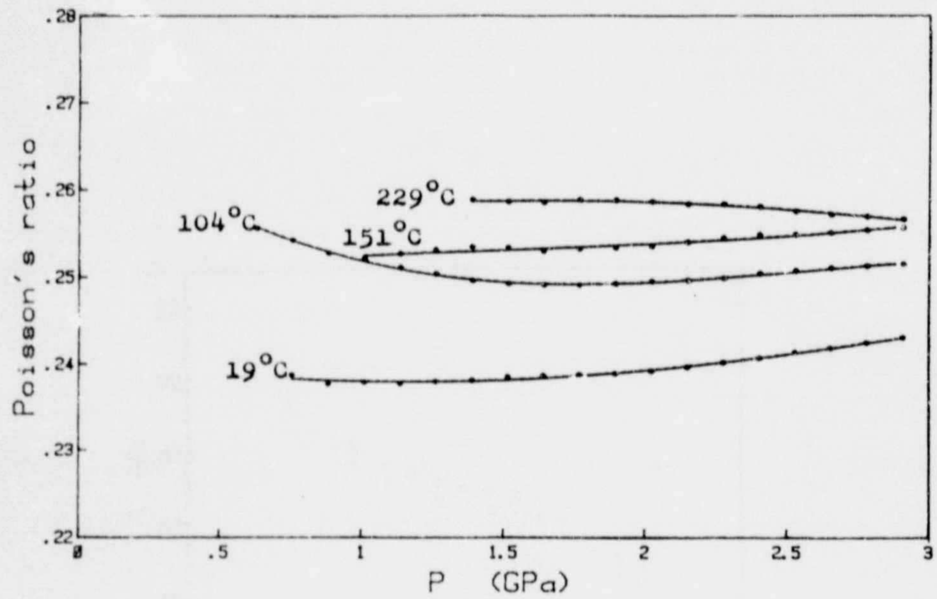

Fig. 5.2.10 9658 GC: Poisson's ratio vs pressure

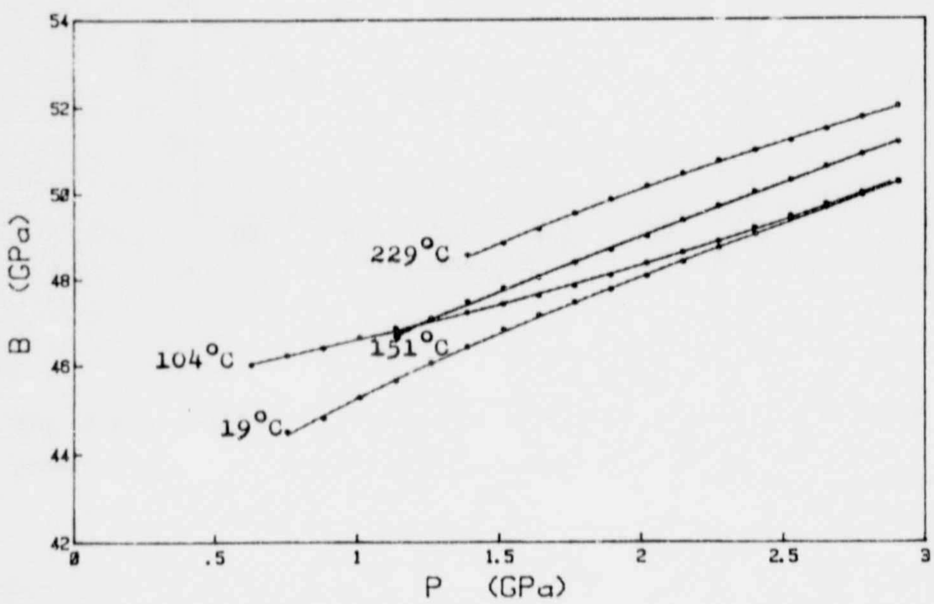

Fig. 5.2.11 9658 GC: Julk modulus vs pressure

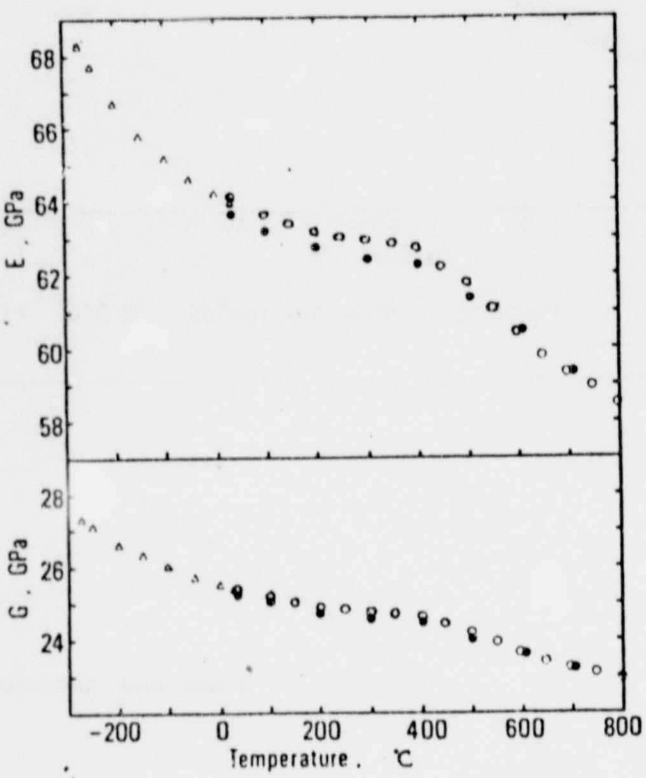

Fig. 5.2.12 9658 GC: Temperature dependence of Young's and shear moduli produced by Nakano, et al. (1987)

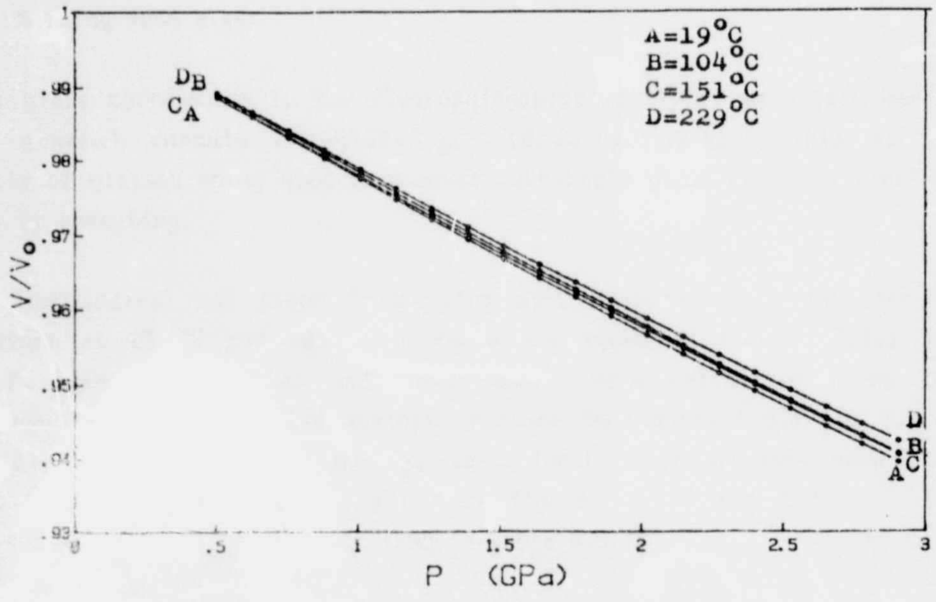

Fig. 5.2.13 9658 GC: Volume variation vs pressure

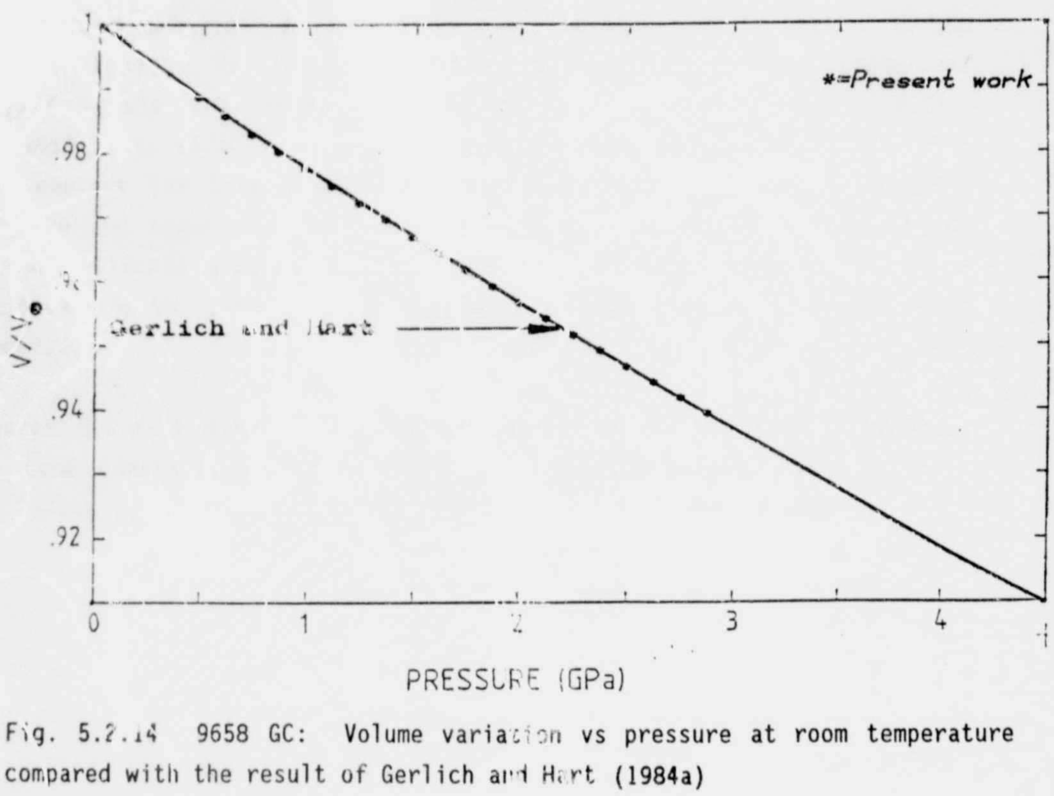

Fig. 5.2.14 9658 GC: Volume variation vs pressure at room temperature compared with the result of Gerlich and Hart (1984a)

5.3 Corning 9658 glass

This glass corresponds to the fluorophlogopite family of materials having the general formula $KMg_3AlSi_2O_{10}F_2$ (Bradley, 1976). This is the family of glasses being used to produce machinable glass ceramics (section 5.2) by annealing.

The longitudinal and shear frequencies were measured as a function of pressure at 23 °C and 103 °C. These are shown in figures 5.3.1 and 5.3.2. The longitudinal and shear moduli were calculated using the frequencies and are plotted against pressure in figures 5.3.3 and 5.3.4. The elastic constants C_{11} and C_{44} as a function of pressure were then calculated using the above data (see figures 5.3.5 and 5.3.6). The polynomial fitted data is summarized in Table 5.3.1.

The longitudinal and shear modes initially soften, but around 2 GPa the rate of softening decreases. Manghnani (1970) pointed out that the degree of anomalous behaviour of a silicate glass is most closely related to the SiO_2 content. He established the relationships between $\partial B/\partial P$ and $\partial C_{44}/\partial P$ versus SiO_2 content in the silicate glasses (Figure 5.3.7). For 9658 glass $\partial B/\partial P$ = -0.61 and $\partial C_{44}/\partial P$ = -0.61 which indicate a ~75 % SiO_2 content for this glass. Manghnani's results also show alternating positive and negative signs for $\partial B/\partial T$ and $\partial C_{44}/\partial T$ for 72 % - 80 % SiO_2 content silicate glasses. This might be the reason why C_{12}, B and σ decrease with temperature, while C_{11}, C_{44} and E increase with temperature.

Figures 5.3.8-11 display the pressure variation of the Young's modulus, the Lamé constant, Poisson's ratio and the bulk modulus, respectively. The volume variation shown in figure 5.3.12 is linear with pressure.

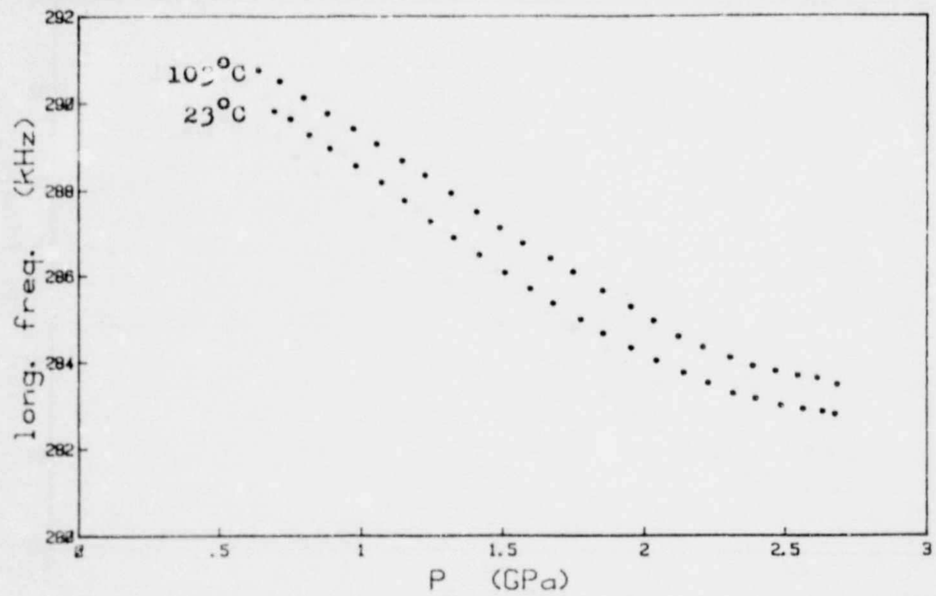

Fig. 5.3.1 9658 glass: Longitudinal frequency vs pressure at temperature

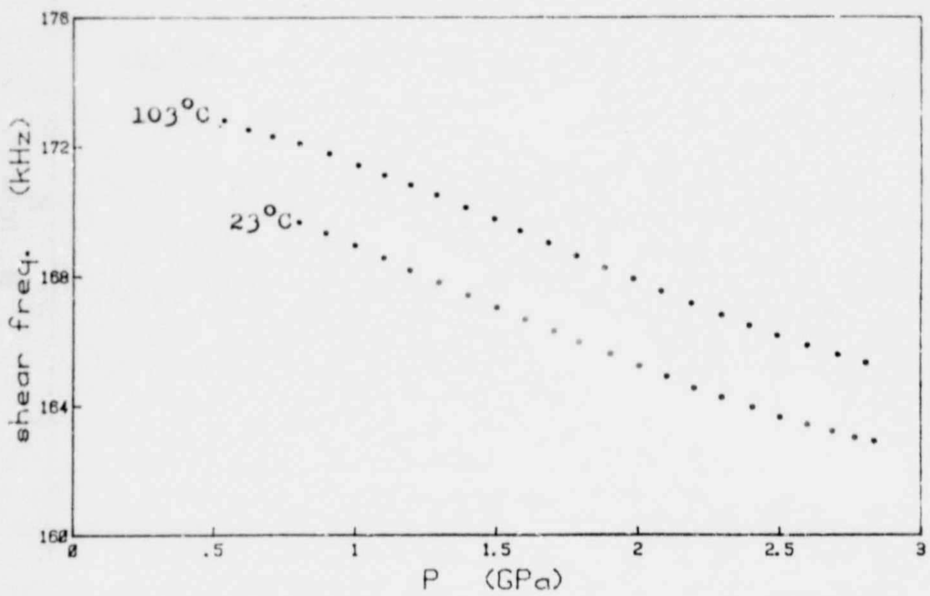

Fig. 5.3.2 9658 glass: Shear frequency vs pressure at temperature

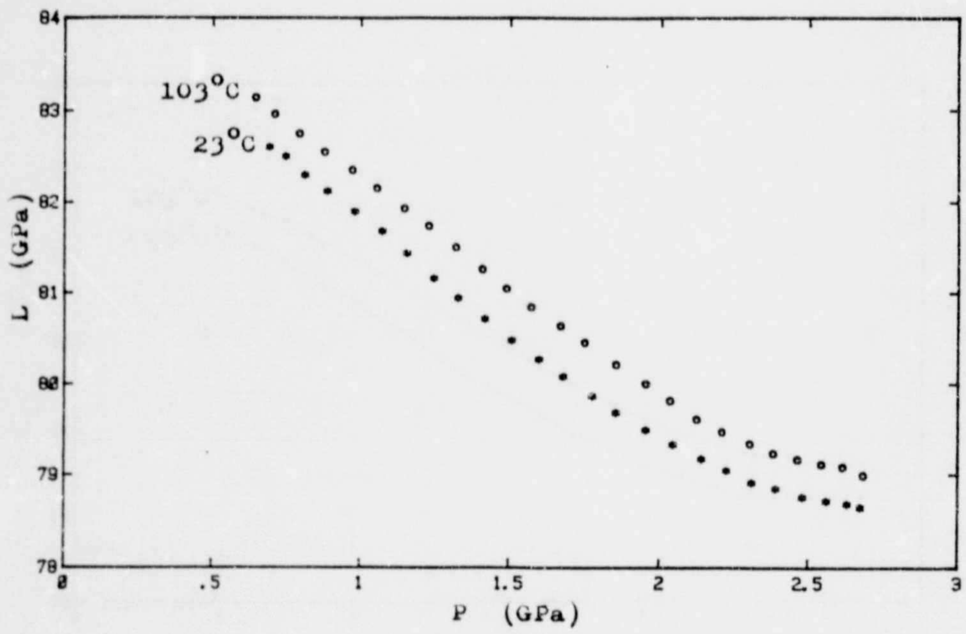

Fig. 5.3.3 9658 glass: Longitudinal modulus vs pressure

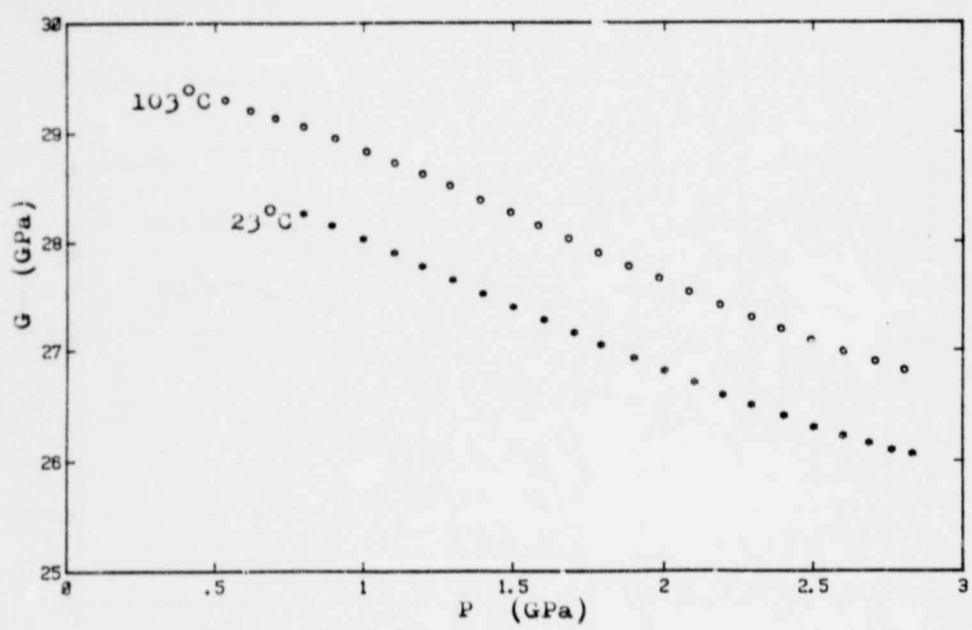

Fig. 5.3.4 9658 glass: Shear modulus vs pressure

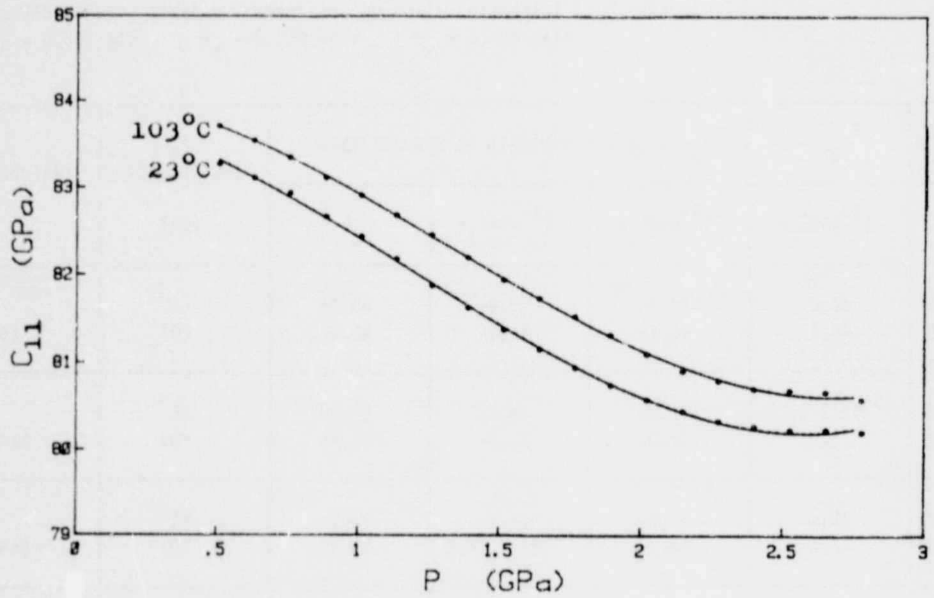

Fig. 5.3.5 9658 glass: C_{11} vs pressure

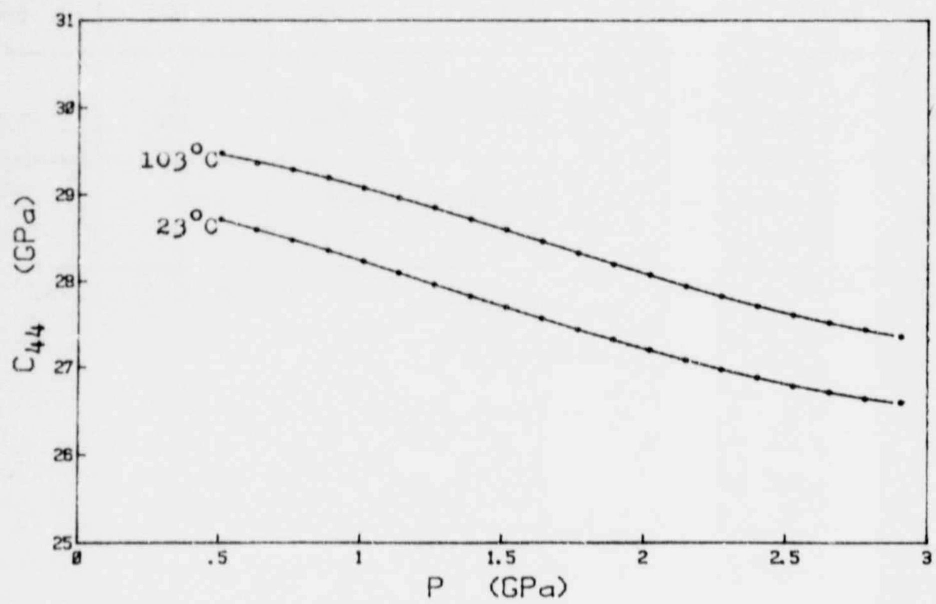

Fig. 5.3.6 9658 glass: C_{44} vs pressure

Table 5.3.1

Corning 9658 Glass: Elastic Properties and their Polynomial Coefficients

Density = 2,496 g/cc v_ℓ = 5,720 km/s v_t = 3,465 km/s

ELASTIC CONSTANT	TEMPERATURE (°C)	COEFFICIENTS OF EQUATION $M = a_0 + a_1P + a_2P^2 + a_3P^3$				$X \leq P \leq Y$ (GPa)	
		a_C	a_1 (GPa^{-1})	a_2 (GPa^{-2})	a_3 (GPa^{-3})	X	Y
C_{11} (GPa)	23	83,84	-0,52	-1,25	0,35	0,5	2,78
	103	84,06	-0,12	-1,36	0,34	0,5	2,78
C_{44} (GPa)	23	29,09	-0,61	-0,34	$8,68 \times 10^{-2}$	0,5	2,91
	103	29,65	-0,12	-0,55	0,11	0,5	2,91
E (GPa)	23	71,96	-1,44	-0,74	0,21	0,76	2,78
	103	72,62	$9,65 \times 10^{-2}$	-1,49	0,32	0,63	2,65
B (GPa)	23	45,55	-0,61	-0,29	0,15	0,76	2,78
	103	44,46	$2,59 \times 10^{-1}$	-0,81	0,24	0,63	2,65
C_{12} (GPa)	23	26,16	-0,20	$-0,74 \times 10^{-1}$	$9,04 \times 10^{-2}$	0,76	2,78
	103	24,75	$2,46 \times 10^{-1}$	-0,38	$1,57 \times 10^{-1}$	0,63	2,65
σ	23	$2,37 \times 10^{-1}$	$1,27 \times 10^{-3}$	$1,42 \times 10^{-3}$	$7,09 \times 10^{-6}$	0,76	2,78
	103	$2,28 \times 10^{-1}$	$7,86 \times 10^{-4}$	$1,02 \times 10^{-3}$	$2,13 \times 10^{-4}$	0,63	2,65
V/V_0	23	1,00	$-0,22 \times 10^{-1}$	$1,93 \times 10^{-4}$		0,76	2,78
	103	1,00	$-0,23 \times 10^{-1}$	$1,79 \times 10^{-4}$		0,76	2,65

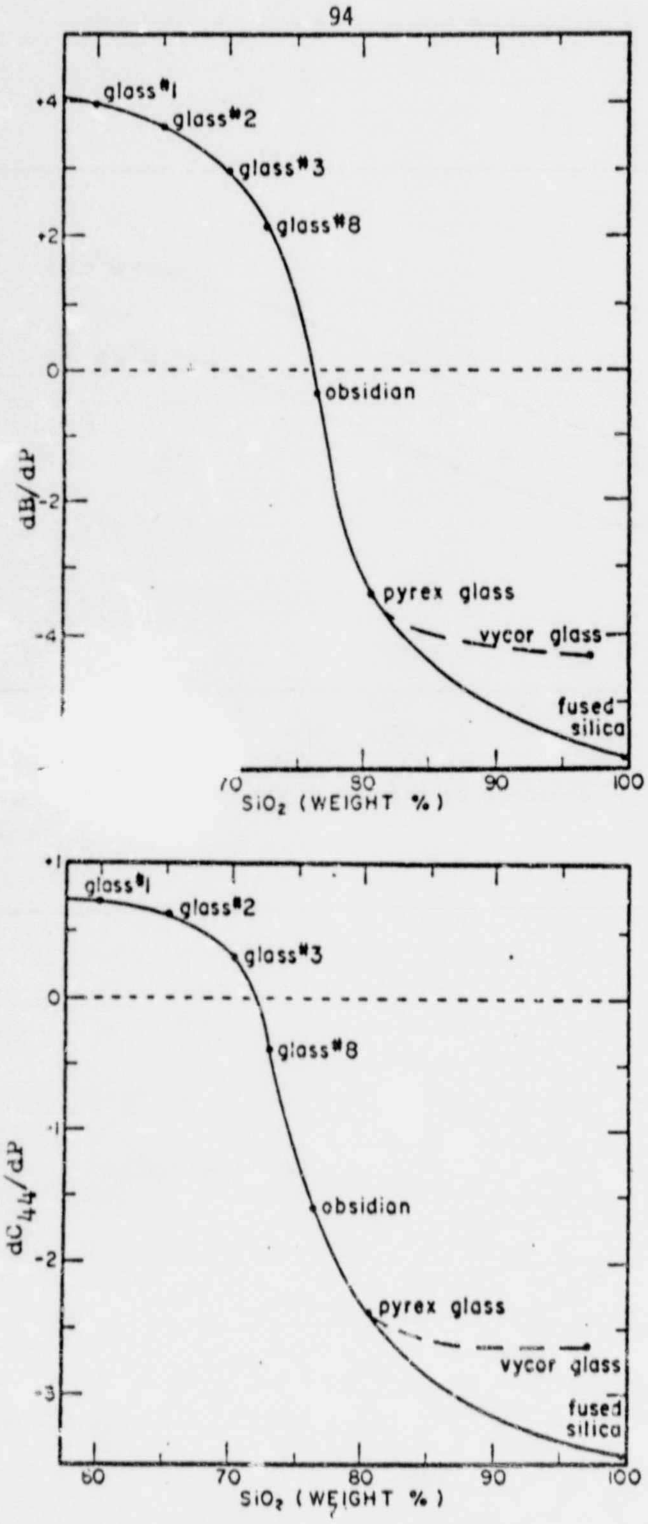

Fig. 5.3.7 The relationships between $\partial B/\partial P$ and $\partial C_{44}/\partial P$, vs SiO_2 content in the silicate glasses (after Manghnani, 1970)

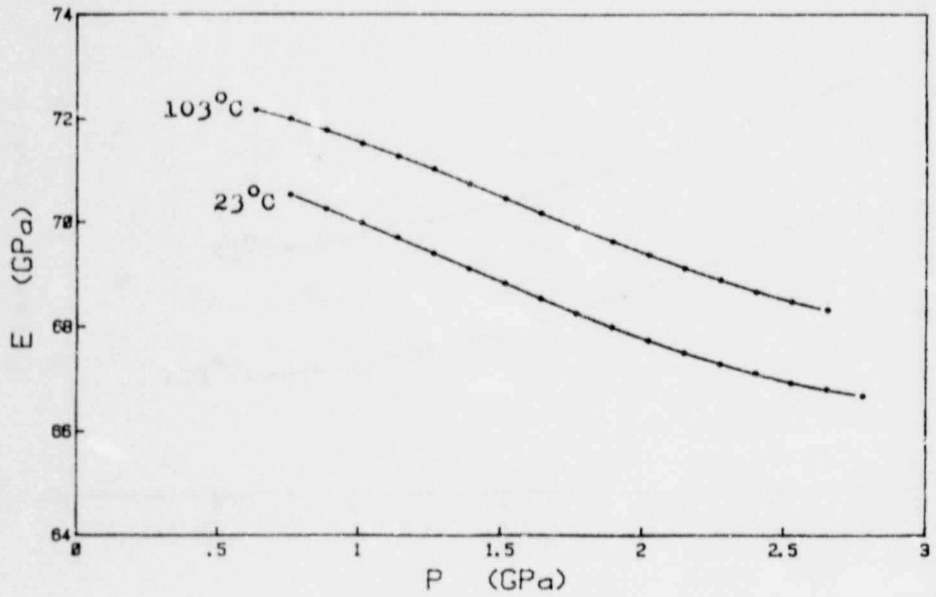

Fig. 5.3.8 9658 glass: Young's modulus vs pressure

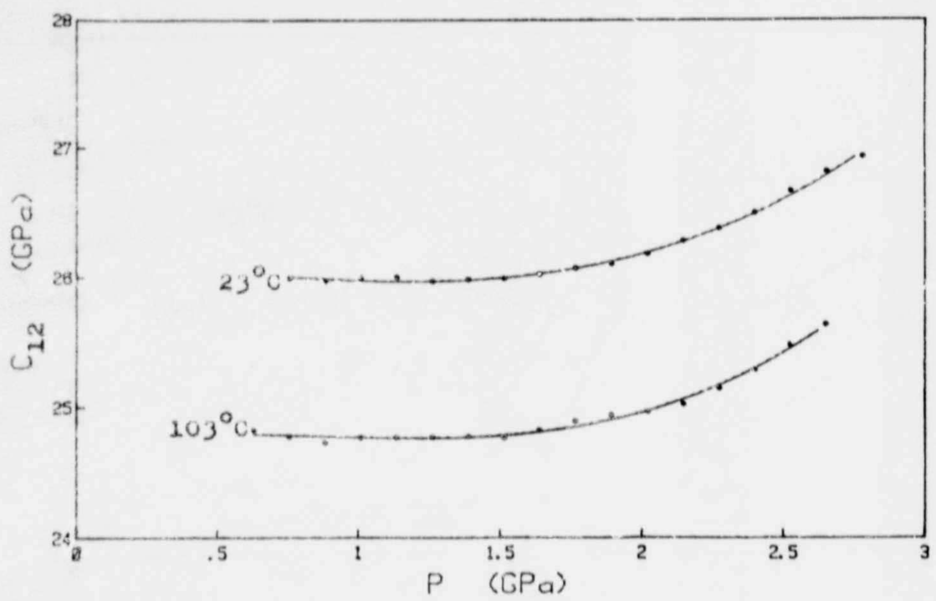

Fig. 5.3.9 9658 glass: Lamé constant vs pressure

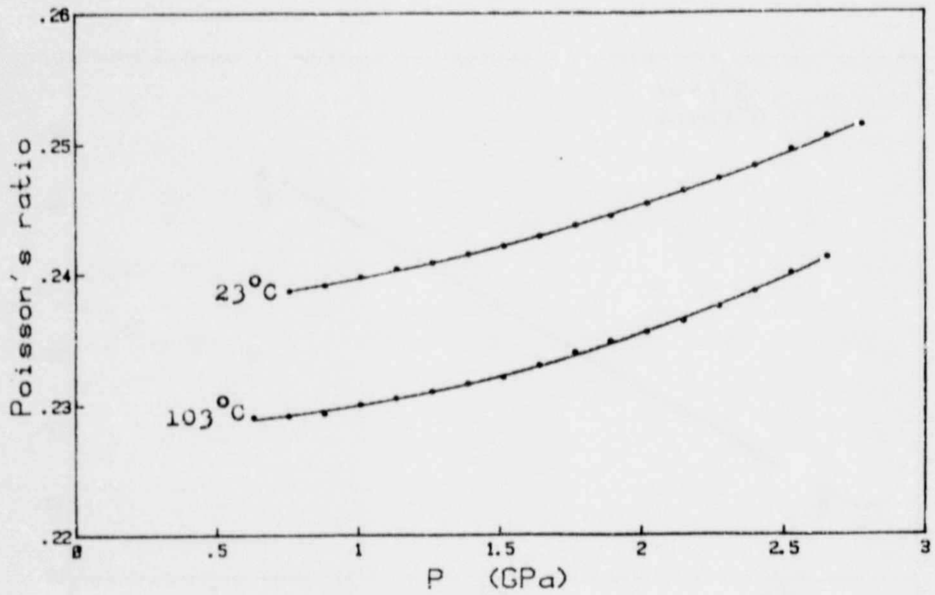

Fig. 5.3.10 9658 glass: Poisson's ratio vs pressure

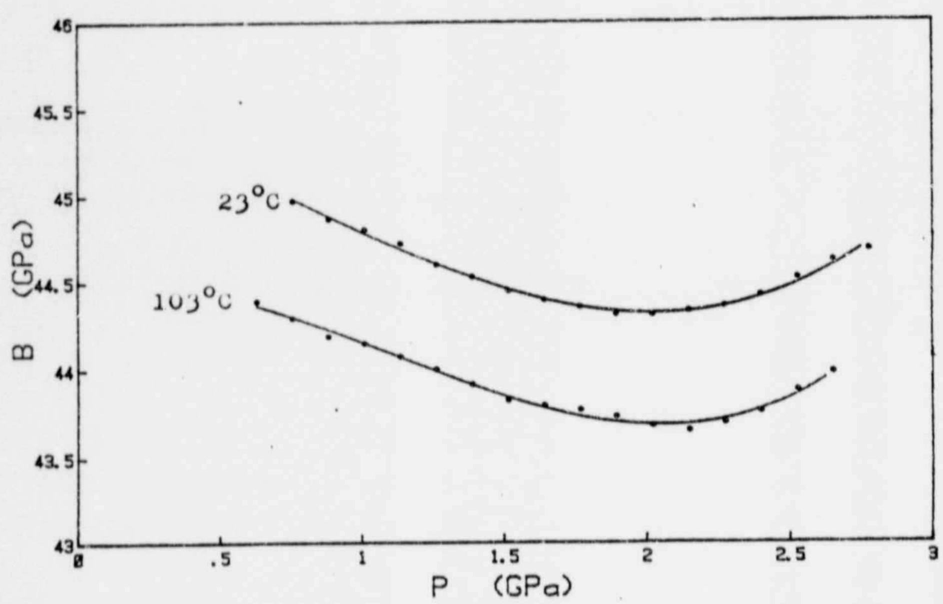

Fig. 5.3.11 9658 glass: Bulk modulus vs pressure

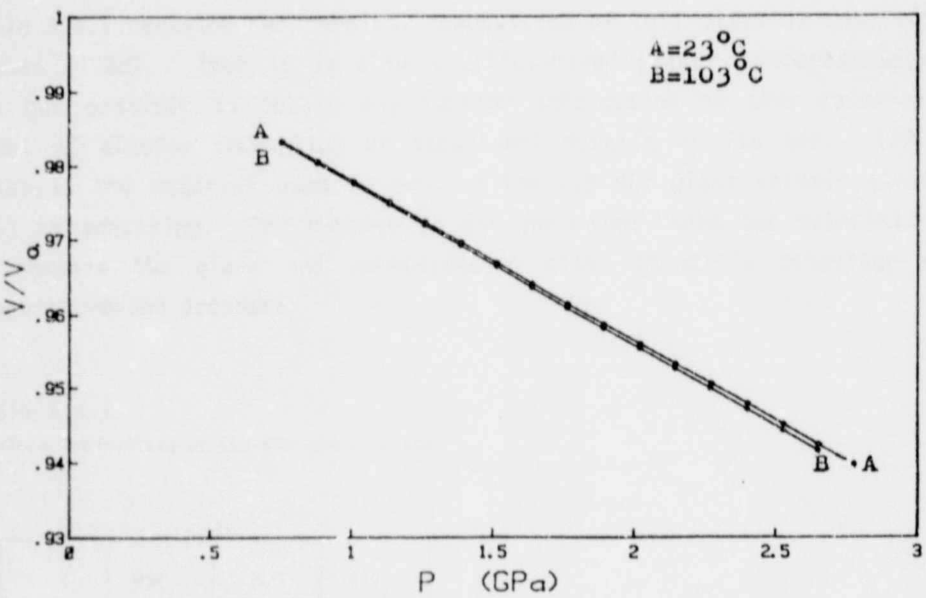

Fig. 5.3.12 9658 glass: Volume variation vs pressure

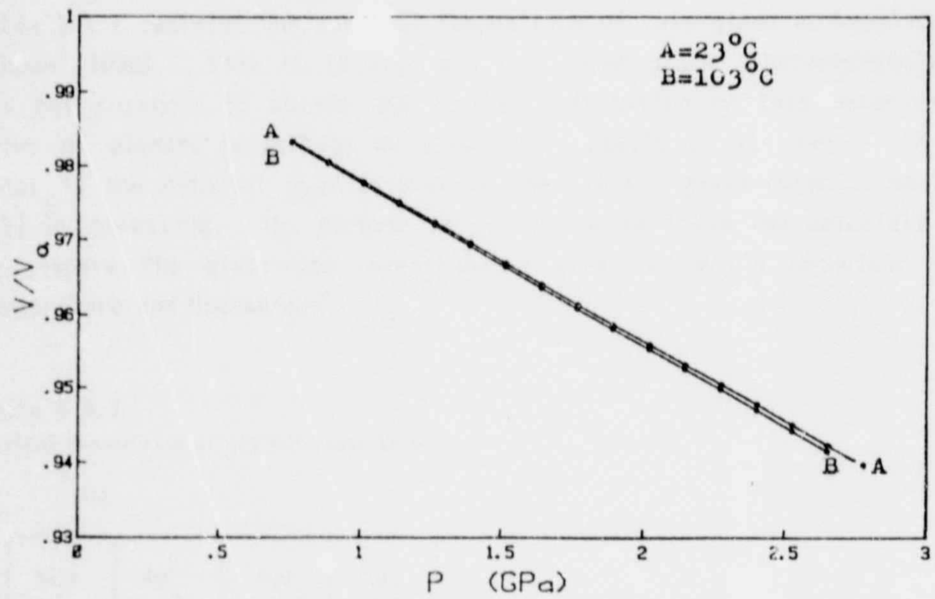

Fig. 5.3.12 9658 glass: Volume variation vs pressure

5.4 119 MCY glass

Table 5.4.1 contains the chemical composition of this glass as supplied by Ashbee (1988). Thus it is also a silica-based glass. Unfortunately it was not possible to obtain any further information on this material in terms of elastic properties or structural details or its use. 119 MCY glass is the material used to produce the 119 MCY glass ceramic (section 5.5) by annealing. The purpose of yet including these two materials was to compare the glass and corresponding glass ceramic's behaviour with temperature and pressure.

Table 5.4.1
Chemical Composition of 119 MCY Glass in wt%

Na_2O	MgF_2	MgO	SiO_2
11,2	5,6	18,2	65,0

Figures 5.4.1 and 5.4.2 show the experimental results for this glass of the frequency versus friction corrected pressure that has been applied for three different isotherms, i.e. 26 °C, 103 °C and 200 °C. In figures 5.4.3 and 5.4.4 the longitudinal and shear moduli are respectively displayed. These have been calculated directly from the former frequency graphs. The values of C_{11} and C_{44} versus pressure as shown in figures 5.4.5 and 5.4.6 are produced by applying Fritz's method to the longitudinal and shear moduli versus pressure.

This glass first stiffens with pressure as shown in the previous graphs. Then at about 1.0 GPa the longitudinal mode stiffens at a lower rate at higher pressure and the shear mode softens strongly after 0.6 GPa. It should be noted that the pressure at which these changeovers are taking place are not temperature dependent.

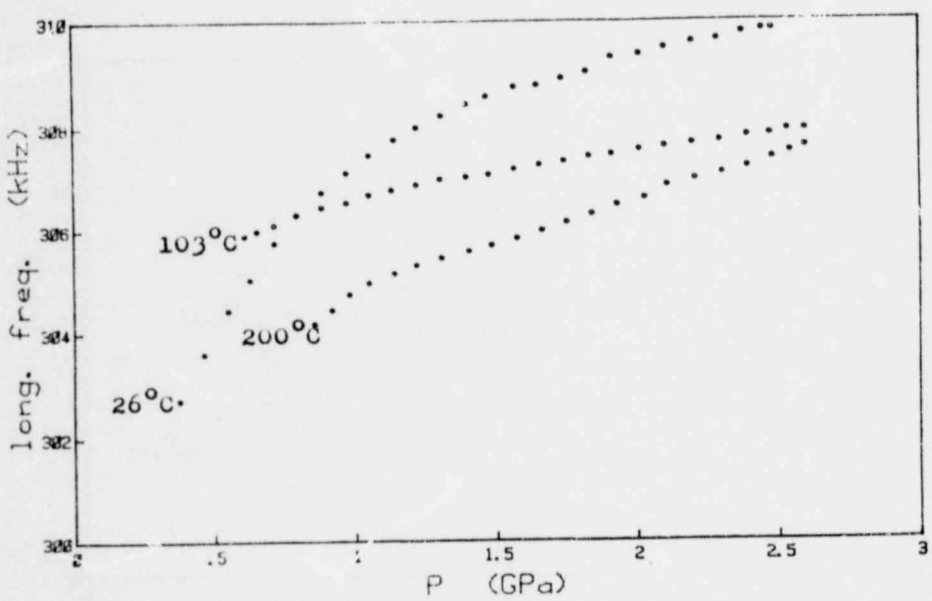

Fig. 5.4.1 119 MCY glass: Longitudinal frequency vs pressure at temperature

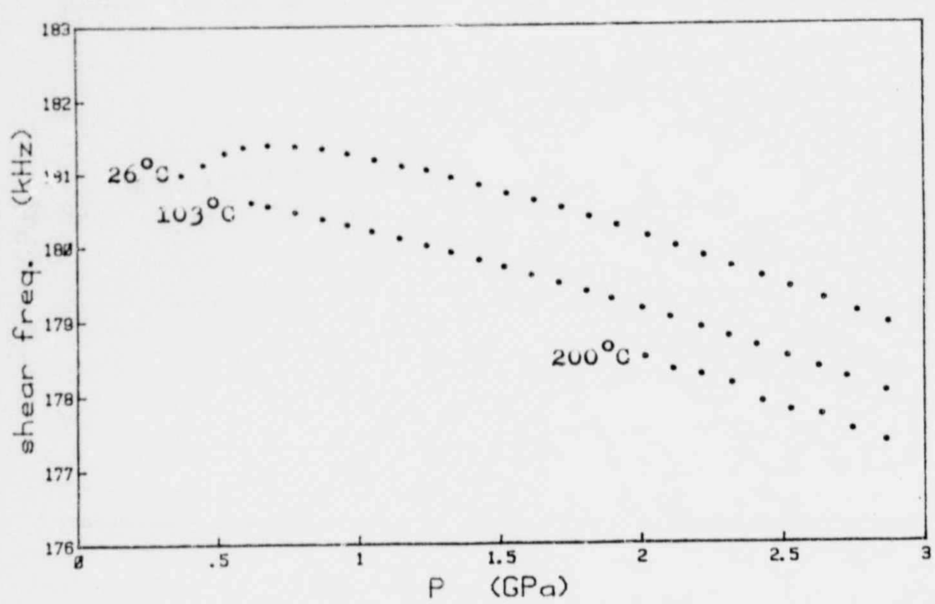

Fig. 5.4.2 119 MCY glass: Shear frequency vs pressure at temperature

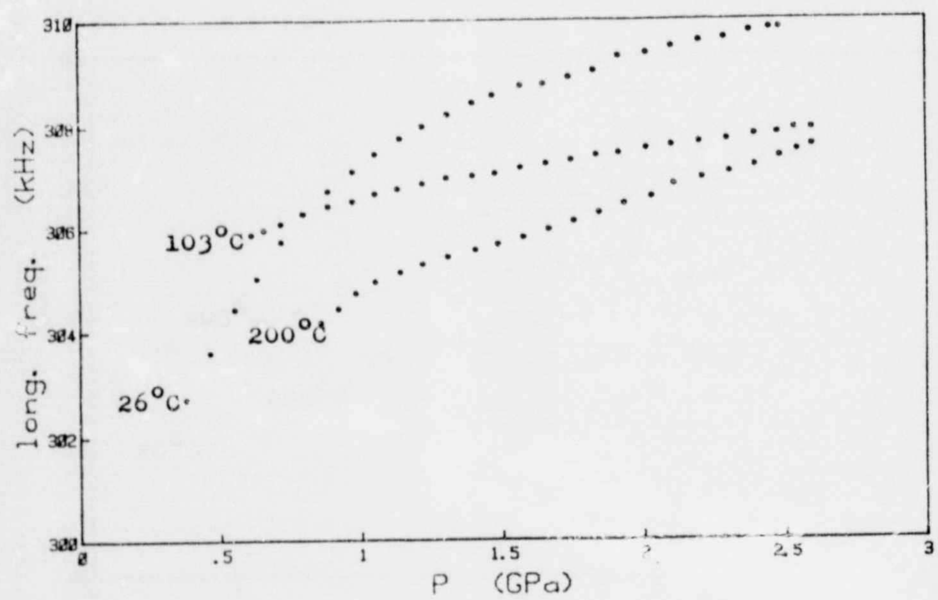

Fig. 5.4.1 119 MCY glass: Longitudinal frequency vs pressure at temperature

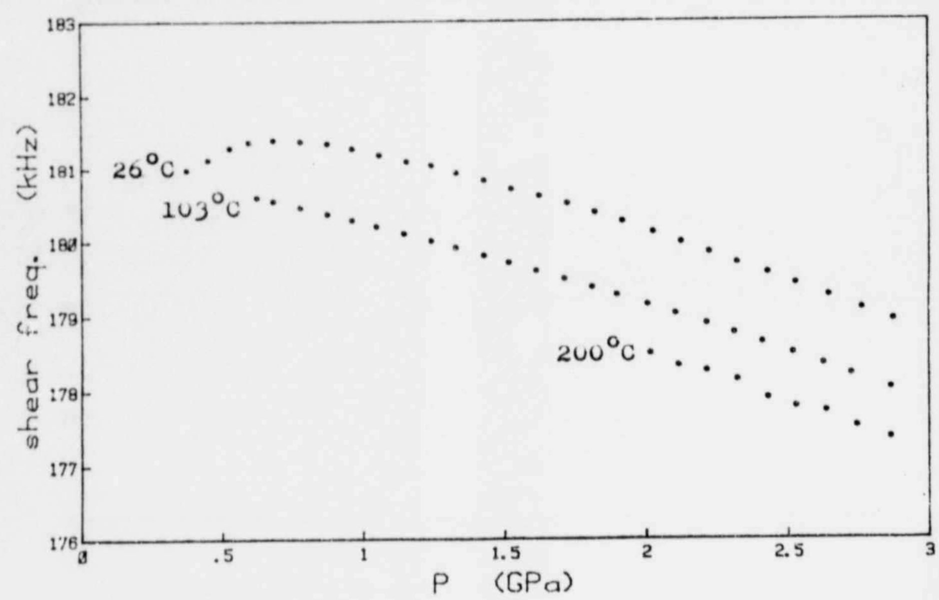

Fig. 5.4.2 119 MCY glass: Shear frequency vs pressure at temperature

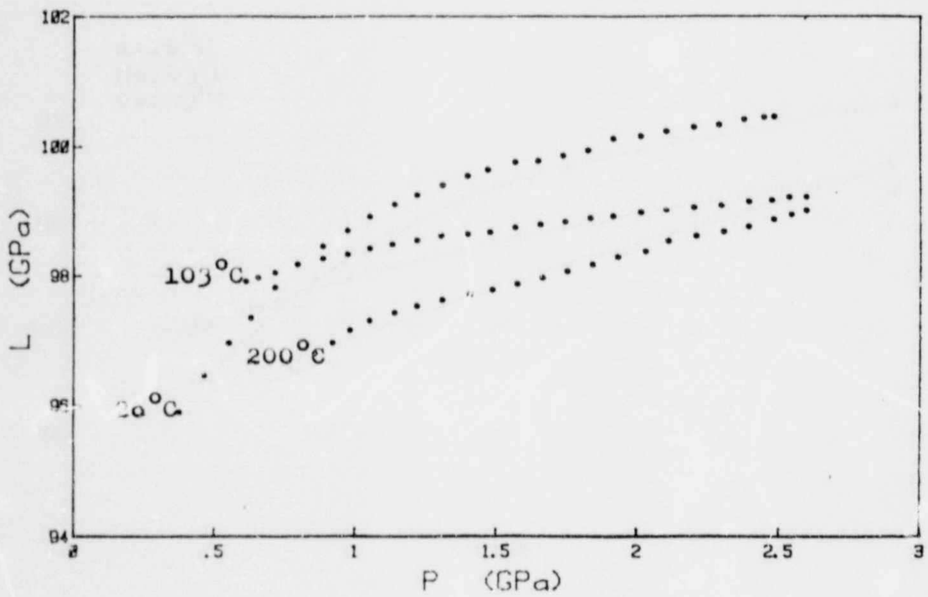

Fig. 5.4.3 119 MCY glass: Longitudinal modulus vs pressure

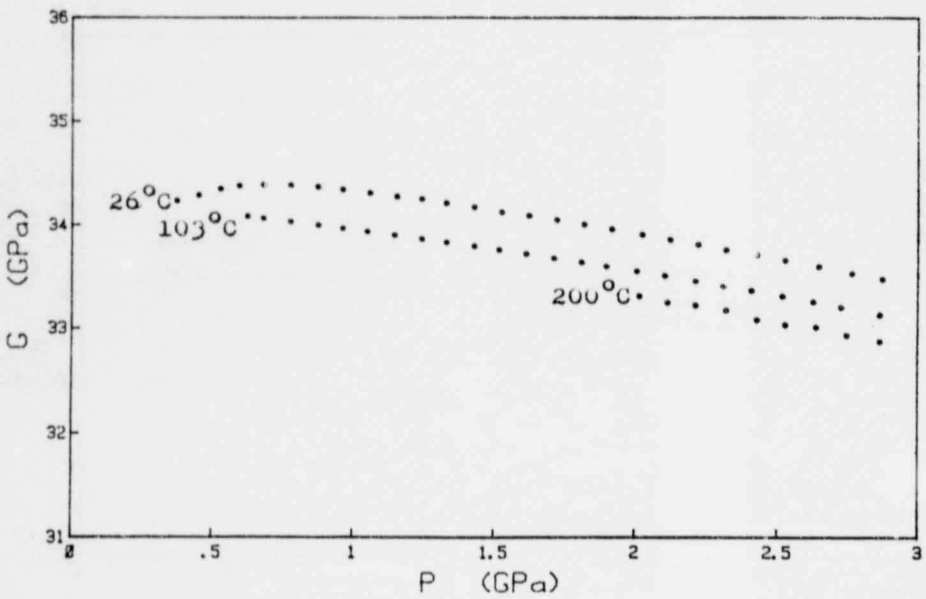

Fig. 5.4.4 119 MCY glass: Shear modulus vs pressure

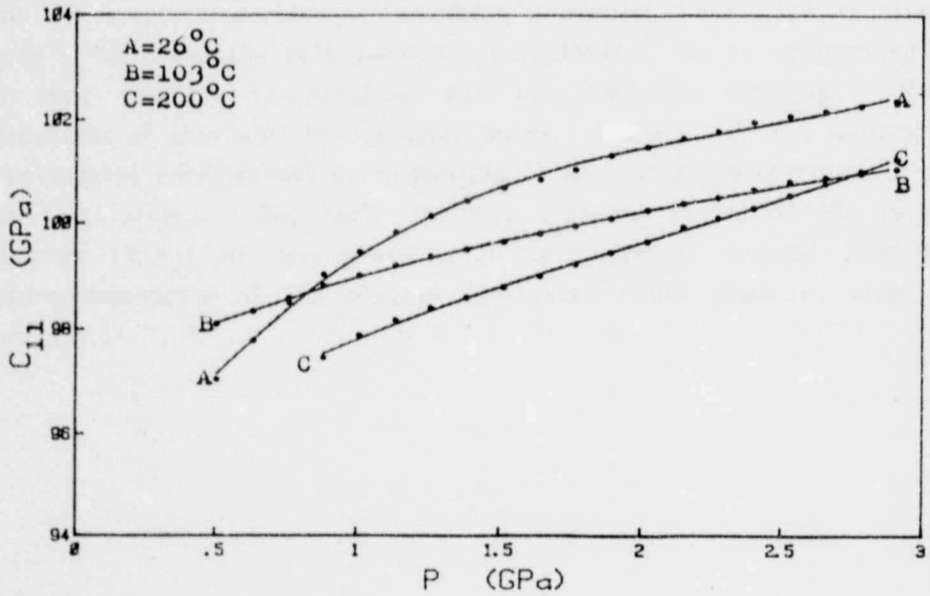

Fig. 5.4.5 119 MCY glass: C_{11} vs pressure

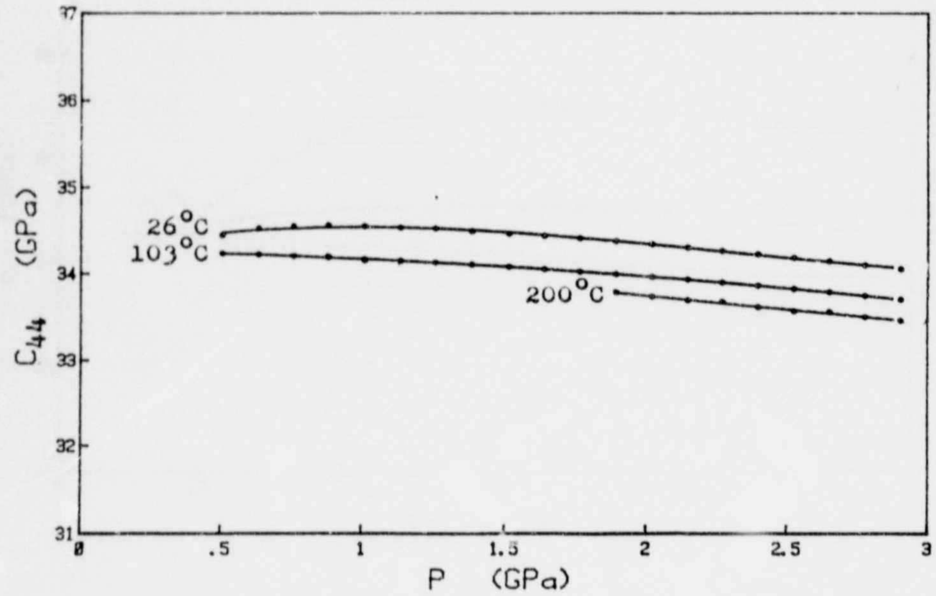

Fig. 5.4.6 119 MCY glass: C_{44} vs pressure