From the figure, it is apparent that for each mode the data are linear within experimental error. Therefore, the pressure dependence of the natural wave velocity W [*Thurston and Brugger*, 1964] is given by

$$W = W_0 + P\left(\frac{dW}{dP}\right)_{P=0} \quad (1)$$

Since W is inversely proportional to the repetition time T_R, and since the data are linear, the following relation holds for any particular mode

$$\left[\frac{\partial(\rho_0 W^2)}{\partial P}\right]_{P=0} = (\rho_0 W^2)_0' = \frac{2w}{P}\left(\frac{T_0 - 1}{T_R}\right) \quad (2)$$

where $w = \rho_0 V_0^2$ (ρ_0 = density, V_0 = actual velocity, both at zero pressure). The expressions for the stiffness coefficients involve linear combinations of the elastic constants and values of ρV^2 for particular modes [*McSkimin*, 1964]. Therefore, the pressure derivatives of the stiffness coefficients explicitly depend on expressions involving $(\rho V^2)_0'$ for particular vibrational modes. These quantities are related to the terms $(\rho_0 W^2)_0'$, which are calculated directly from the pressure data using (2), by the following expression [*Thurston and Brugger*, 1964]:

$$-(\rho V^2)_0' = -(\rho_0 W^2)_0' + 2wN_k N_m S_{kmaa}{}^T - wS_{iiaa}{}^T \quad (3)$$

where the summation convention is implied and $S_{ijkl}{}^T$ are the second-order isothermal elastic compliances. The various experimental data and the final isothermal pressure derivatives of the effective second-order elastic stiffness coefficients are presented in Table 3.

The internal cross checks resulting from the symmetry characteristics of forsterite, provide a direct means of testing the accuracy of the pressure derivatives, as well as the absolute values of the coefficients $c_{ij}{}^S$. Separate pressure measurements were carried out for each of the vibrational modes from which c_{66} is determined. In addition, the pressure derivatives of c_{23} were calculated from both the 'quasi-shear' (QS) and 'quasi-longitudinal' (QP) modes. The agreement is quite good in both instances. Based upon the indication of error afforded by these cross checks, it seems reasonable to conclude that the derivative values of the on-diagonal moduli are accurate to within ±1%, and those of the cross-coupling coefficients to within ±2%.

Temperature dependence of the elastic constants at 1 atmosphere. The basic experimental data necessary to determine the temperature dependence of the 9 stiffness coefficients are the delay time T_R as a function of temperature. Since the thermal expansion of forsterite has been measured [*Skinner*, 1962], the quantities ρV^2 for each vibrational mode may be measured directly as a function of temperature by making the appropriate density and specimen length corrections. The function

TABLE 3. Experimental Values of $\Delta(T_0/T_R - 1)/\Delta P$ and $w = \rho_0 V_0^2$, the Calculated Values of $(\rho_0 W^2)_0'$, and the Isothermal Pressure Derivatives of the Effective Adiabatic Stiffnesses $(c_{ij}{}^S)_0'$ for the Various Measured Modes

Stiffness	$\bar{N}$	$\Delta(T_0/T_R - 1)/\Delta P$, $\times 10^3$ kb	w, kb	$(\rho_0 W^2)_0'$	$(c_{ij}{}^S)_0'$
$c_{11}{}^S$	[100]	10.48	3290.5	6.897	8.315
$c_{22}{}^S$	[010]	14.26	2004.5	5.717	5.925
$c_{33}{}^S$	[001]	11.85	2363.1	5.601	6.213
$c_{44}{}^S$	[010]	15.25	672.30	2.050	2.120
$c_{55}{}^S$	[100]	7.980	814.44	1.300	1.651
$c_{66}{}^S$	[010]	13.77	811.41	2.235	2.319 } 2.316*
	[100]	12.10		1.964	2.313 }
$c_{12}{}^S$	[*lm*0]	6.40	928.8	1.188	4.30
$c_{13}{}^S$	[*l*0*n*]	6.13	1023.0	1.194	4.23
$c_{23}{}^S$	[0*mn*]QP	15.08	703.7	6.488	3.554 } 3.53*
	[0*mn*]QS	8.16		1.177	3.52 }

* Recommended values.

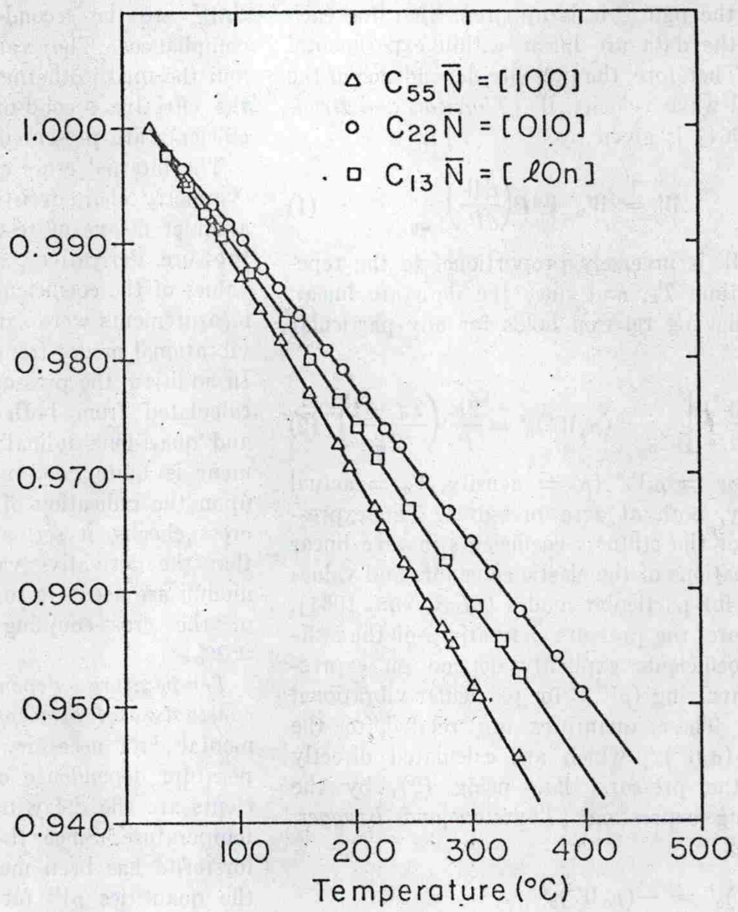

Fig. 2. Normalized adiabatic elastic coefficients as a function of temperature for three representative modes.

TABLE 4. The Isobaric Temperature Derivatives of the Adiabatic Stiffness Coefficients for $T > 200°C$

Stiffness	N̄	$(\partial c_{ij}{}^S/\partial T)_P$, kb/°C	
$c_{11}{}^S$	[100]	−0.389	
$c_{22}{}^S$	[010]	−0.311	
$c_{33}{}^S$	[001]	−0.269	
$c_{44}{}^S$	[010]	−0.139	
$c_{55}{}^S$	[100]	−0.144	
$c_{66}{}^S$	[100]	−0.165	−0.163*
	[010]	−0.161	
$c_{12}{}^S$	[$lm0$]	−0.117	
$c_{13}{}^S$	[$l0n$]	−0.087	
$c_{23}{}^S$	[$0mn$]	−0.092	

* Recommended value.

$c_{ij}(T)/c_{ij}(T_0)$, where the reference temperature $T_0 = 25°C$, is plotted in Figure 2 for three representative modes. The data are essentially linear for temperatures above $T = 200°C$. Since the linear temperature derivatives $(\partial c_{ij}{}^S/\partial T)_P$ for $T > 200°C$ may be used to determine the elastic behavior of forsterite at very high temperatures [*Soga et al.*, 1966], these quantities are of primary concern. The linear isobaric temperature derivatives of the adiabatic stiffness constants, applicable in the range $T > 200°C$, are presented in Table 4.

The temperature dependence of the shear coefficient c_{66} has been measured using the two independent pure shear modes indicated in Table 4. The deviation, although small, is sig-