polynomial could not be justified for any of the shear or quasi-shear modes, with the exception of three modes belonging to the moduli c_{44} and c_{55}. These three modes represent borderline cases and were for the sake of uniformity also fitted to second-order polynomials.

In all, 23 pressure tests were performed on the four specimens used in this study. In this way many cross checks of the pressure dependence of the elastic constants resulting from different propagation directions in the specimens could be examined for consistency. As typical examples of unprocessed pressure data, the normalized quantity $(t_0/t_r)^2 = (W/W_0)^2$, where t_0 denotes the transit time at zero pressure, is plotted versus pressures for the modes corresponding to the on-diagonal longitudinal moduli (Figure 2) and for those corresponding to the shear modulus c_{55} and the cross-coupling modulus c_{13} (Figure 3). To illustrate the nonlinearity for the shear modes, the initial slope for N = [001] and U = [100] (c_{55}) (Figure 3) has been linearly extrapolated to higher pressures. It is also apparent (Figure 3) that the quasi-shear mode corresponding to c_{13} also shows a distinctly nonlinear behavior. All solid lines in this figure represent the quadratic least-squares fit according to

$$(W/W_0)^2 = (t_0/t_r)^2$$
$$= 1 + (W^2/W_0^2)'P + (W^2/W_0^2)''P^2/2 \quad (2)$$

For calculating the first pressure derivatives of the elastic constants from the measured values of $(\rho_0 W^2)'$, the isothermal single-crystal bulk modulus K_0^T and the isothermal compliance coefficients $S_{\mu\nu}^T$ are required. The adiabatic single-crystal bulk modulus can be determined from the general expression

$$K_0^S = (S_{iijj}^S)^{-1} \quad (3)$$

and converted to its isothermal counterpart by *Overton*'s [1962] equation 2. This equation gives $K_0^S = 1.021$ Mb and $K_0^T = 0.998$ Mb.

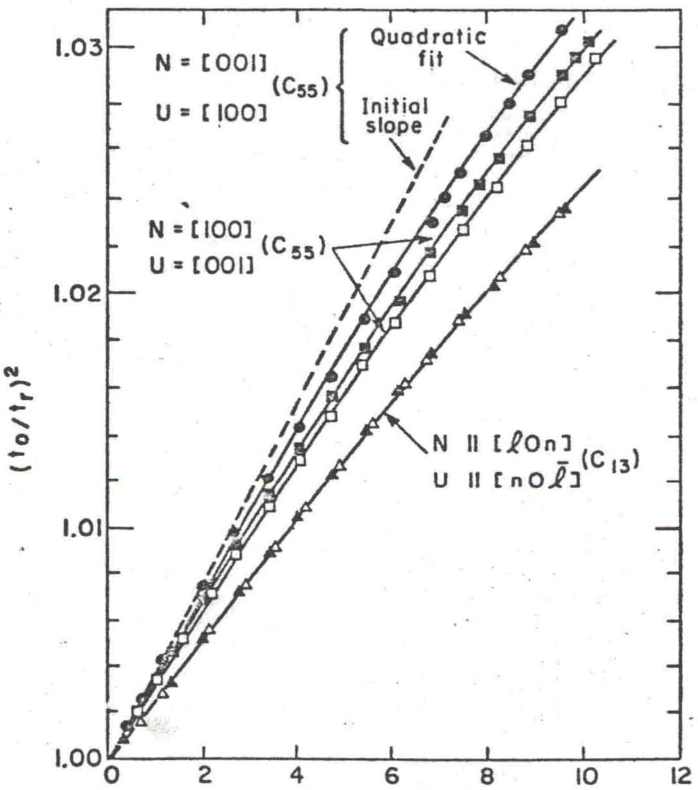

Fig. 3. Experimental data of $(t_0/t_r)^2$ as a function of pressure for the elastic moduli c_{55} and c_{13}. Solid squares and solid circles indicate specimen 1; open squares, specimen 3; solid and open triangles, specimen 4.

TABLE 6. Adiabatic and Isothermal Elastic Compliance Coefficients at 25°C (All values in Mb^{-1}.)

Coefficient	Adiabatic	Isothermal
s_{11}	0.5253	0.5259
s_{22}	0.7453	0.7474
s_{33}	0.5231	0.5259
s_{44}	1.223	1.223
s_{55}	1.325	1.325
s_{66}	1.288	1.288
s_{12}	-0.2053	-0.2029
s_{13}	-0.0914	-0.0886
s_{23}	-0.1095	-0.1070

The adiabatic compliance coefficients can be determined by inversion of the adiabatic elastic-constant matrix, and the isothermal compliance coefficients can be calculated from *Thurston* [1967]:

$$S_{ijkl}^{T} = S_{ijkl}^{S} + (T\alpha_{ij}\alpha_{kl}/\rho_0 C_P) \quad (4)$$

where α_{ij} are the linear thermal-expansion coefficients, T is the temperature, and C_p is the specific heat at constant pressure. The thermal-expansion coefficients of bronzite used were determined by *Frisillo and Buljan* [1972], and the specific heat was calculated from the present elastic data [*Anderson*, 1965]. The value obtained for $C_p = 94.66$ mole^{-1} °K^{-1}. The adiabatic elastic compliances are tabulated in Table 6 together with the isothermal values calculated from the preceding data.

First pressure derivatives of effective second-order elastic constants. The isothermal first pressure derivatives of the adiabatic effective elastic constants were calculated by using the equations given by *Graham* [1969] and *Barsch and Frisillo* [1973] (Table 7). The internal cross checks resulting from orthorhombic symmetry coupled with checks from the four different specimens show excellent agreement in the computed values.

Because an intercrystal check on the pressure derivatives of c_{33} was not possible, the reliability of the measured values was examined by making two independent pressure runs. Although the cross-coupling moduli may also be determined by propagation of quasi-longitudinal modes, their echoes became very small and nondistinct at pressures of about 4.5 kb and were not detected by the automatic peak finder. Because this phenomenon was observed for all longitudinal pressure runs, all longitudinal data above approximately 4.5 kb were taken manually (i.e., without the automatic peak finder). Because a small but significant amount of curvature was observed for all shear moduli and because the manually taken data were not precise enough to describe this curvature, consistency for the pressure derivatives of the cross-coupling coefficients was again determined by repeating the quasi-shear pressure runs. A single quasi-longitudinal run was performed for propagation direction $\mathbf{N} = [0mn]$ and polarization $\mathbf{U} = [0mn]$ and was then used as a consistency check for $(\partial c_{23}/\partial P)_T = c_{23}'$ and as an independent check on the accuracy of c_{33}'. An independent check on c_{33}' results from considering the expressions given by *Fisher and McSkimin* [1958] to calculate the direction cosines for propagation direction $\mathbf{N} = [0mn]$:

$$m^2 = \frac{\rho V_{QS}^2 + \rho V_{QP}^2 - (c_{33}^S + c_{44}^S)}{c_{22}^S - c_{33}^S} \quad (5)$$

where $m^2 + n^2 = 1$. By differentiating (5) with respect to pressure and solving for c_{33}', the following expression is obtained:

$$c_{33}' = \{[(\rho V_{QP}^2)' + (\rho V^2)_{QS}' - c_{44}']n - (\rho V_{QP}^2 + \rho V_{QS}^2 - c_{44})2n' - (2m'c_{22} + mc_{22}')nm + 2m^2n'c_{22}\}/n^3 \quad (6)$$

Here m' and n' denote the first pressure derivatives of the direction cosines, which can be cal-