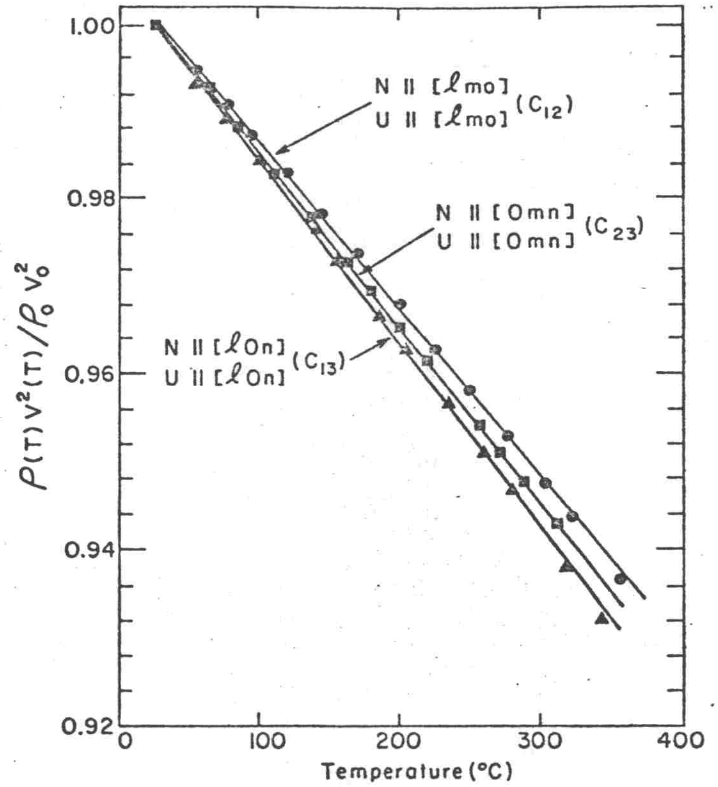

Fig. 5. Experimental data of ρV^2 (referred to the value at $T_0 = 25°C$) for the quasi-shear modes used to determine the cross-coupling moduli c_{12}, c_{13}, and c_{23} as a function of temperature. Circles indicate specimen 2; squares, specimen 3; triangles, specimen 4.

cross-coupling moduli are presented in Table 10. The stated errors and the weighted averages and their errors have been determined by using the error propagation method and (7) and (8), respectively.

DISCUSSION

Comparison of bronzite data with those of other authors and for other materials of geophysical interest. The single-crystal elastic constants of orthopyroxene at room temperature and 1 atm have been measured previously by *Ryzhova et al.* [1966] and *Kumazawa* [1969]. The elastic constants of orthopyroxene from these authors are compared with the results presented here (Table 11). Because the specimen used by *Ryzhova et al.* [1966] had a large porosity (1.8%), their reported values are significantly low in some cases. The present data and those of Kumazawa, however, compare favorably, the elastic constants in the present study being somewhat smaller, apparently owing to the increased iron concentration. Because values for c_{33} and c_{12}, however, are higher than

TABLE 10. Isobaric Temperature Derivatives of the Cross-Coupling Elastic Constants at 25° to 350°C

Elastic Constant	Specimen	$\vec{N}$	$\vec{U}$	$[\partial(\rho V^2)/\partial T]_{p=0}$, kb °C^{-1}	$[\partial c_{\mu\nu}/\partial T]_{p=0}$, kb °C^{-1}
c_{12}	2	[$lm0$]	[$lm0$]	-0.417	-0.212 ± 0.007
c_{13}	4	[$l0n$]	[$l0n$]	-0.462	-0.318 ± 0.008
c_{23}	3	[$0mn$]	[$0mn$]	-0.388	-0.107 ± 0.007

TABLE 11. Comparison of Adiabatic Single-Crystal Elastic Constants $c_{\mu\nu}^{S}$ of Orthopyroxene with Those of Other Investigators at 25°C (All values in Mb.)

$\mu\nu$	Present Work ($Mg_{0.8}Fe_{0.2}SiO_3$)	*Kumazawa* [1969] ($Mg_{0.84}Fe_{0.16}SiO_3$)	*Ryzhova et al.* [1966] (Not Analyzed)
11	2.286	2.299	1.876
22	1.605	1.654	1.578
33	2.104	2.057	2.085
44	0.8175	0.8306	0.700
55	0.7548	0.7637	0.592
66	0.776	0.7853	0.544
12	0.710	0.701	0.586
13	0.548	0.573	0.605
23	0.460	0.496	0.561

those of Kumazawa, careful consideration was given to checking the n conditions for these modes that might cause such disagreement. No such error was found in the present study.

The isotropic elastic constants of bronzite and their derivatives with respect to pressure and temperature as calculated from the single-crystal data by means of the Voigt-Reuss-Hill (VRH) approximation are compared with some experimental data on polycrystalline bronzite containing 10% enstatite [*Chung*, 1971] (Table 12). Also included for comparison in this table are the isotropic properties of 20% fayalite olivine obtained by *Graham* [1970] by linearly extrapolating his single-crystal data on the pure end-member Mg_2SiO_4 [*Graham and Barsch*, 1969] and those of *Kumazawa and Anderson* [1969] on $(Mg_{0.93}Fe_{0.07})_2SiO_4$. In addition, isotropic elastic-property data of garnet of the almandine pyrope variety [*Soga*, 1967] are presented. It is apparent that the densities, the bulk moduli, and the shear moduli of the two bronzite specimens are rather similar but that the values of $(\partial K^S/\partial P)_T$ differ by almost a factor of 2. Without further systematic work on well-characterized polycrystalline specimens, any attempt to explain this large discrepancy would be merely speculative. The elastic data

TABLE 12. Comparison of Isotropic Moduli and Pressure and Temperature Derivatives of Bronzite ($Mg_{0.8}Fe_{0.2}SiO_3$) with Those of Polycrystalline Bronzite ($Mg_{0.9}Fe_{0.1}SiO_3$), Olivine, and Garnet at 25°C

Parameter	Bronzite*	Bronzite, 10% Enstatite†	Olivine, 20% Fayalite§	Almandine-Pyrope Garnet¶
ρ, g/cm^3	3.354	3.273	3.459	4.160
K^S, Mb	1.035	1.06	1.256	1.770
K^T, Mb	0.9878		1.226	1.757
$(\partial K^S/\partial P)_T$	9.59	5.3	5.09	5.43
$(\partial K^T/\partial P)_P$	9.47		5.16	5.45
$(\partial K^S/\partial T)_P$, kb/°C	-0.268		-0.193	-0.201
$(\partial K^T/\partial T)_P$, kb/°C	-0.296		-0.223	-0.201
G, Mb	0.755	0.768	0.788	0.943
$(\partial G/\partial P)_T$	2.38		1.74	1.400
$(\partial G/\partial T)_P$, kb °C	-0.119		-0.142	-0.106

*From this study.
†From *Chung* [1971].
§From *Graham* [1970].
¶From *Soga* [1967].