



FIG. 4. Variation of temperature derivatives of the elastic constants of olivine with (Fe/Mg) ratio. High-temperature values evaluated at the Debye temperature of each olivine are indicated with a dotted line. (G) stands for Graham's (1970) work and (KA) indicates work of Kumasawa & Anderson (1969); (○) are the present work.

the  $(dK_s/dT)$  value of forsterite is  $-0.131 \text{ kb}/^\circ\text{K}$ , and for fayalite the  $(dK_s/dT)$  value is  $-0.138 \text{ kb}/^\circ\text{K}$ .

Whether an elastic constant is a unique function of volume or not is an important question often asked by geophysicists. The answer to this question forms a basis of the so-called 'Law of Corresponding State' in thermodynamics of solids. An important consequence of the elasticity data reported here is that we can examine the above question in a systematic manner. The elastic constant  $M_j$  of olivine can be treated as a function of volume (thus interatomic separation) and temperature.

$$M_j = M_j(V, T). \quad (8)$$

Taking logarithms and differentiating both sides with respect to temperature and rearranging the results, we find

$$(\text{total}) = (\text{implicit}) + (\text{explicit})$$

$$\frac{d \ln M_j}{dT} = -\alpha_v K_T \left( \frac{\partial \ln M_j}{\partial p} \right)_T + \left( \frac{\partial \ln M_j}{\partial T} \right)_V. \quad (9)$$

Hence, from the present data on both the pressure and temperature derivatives of the elastic constants, we should be able to separate out the *changes* due to temperature from those due to volume. Table 4 lists the pressure and temperature coefficients of compressional ( $L_s$ ) and shear ( $\mu$ ) moduli along with those of the adiabatic bulk modulus ( $K_s$ ). The quantities of interest here are  $(\partial \ln M_j / \partial T)_V$  which are found from our experimental data; they are listed in the last column of Table 4. If the elastic constants are a function of volume alone, i.e.  $M_j = M_j(V)$ , then we would expect the quantity represented by the explicit term to be zero. But it is evident from Table 4 that this explicit term is a non-zero value implying the elastic constants are not a function of volume alone.\* Most crystalline solids of geophysical interest

Table 4

*Test on the volume-dependence Hypothesis of the elastic constants (at 296° K)*

Olivine composition, mole %	$\alpha_p$ $10^{-5}/^\circ\text{K}$	$M_j$	$\frac{d \ln M_j}{dT}$ $10^{-5}/^\circ\text{K}$	$\alpha_v K_T \left( \frac{\partial \ln M_i}{\partial p} \right)_T$ $10^{-5}/^\circ\text{K}$	$\left( \frac{\partial \ln M_i}{\partial T} \right)_V$ $10^{-5}/^\circ\text{K}$
100 Fo	2.55	$L_s$	-12.6	+10.4	-2.2
		$\mu$	-15.6	+7.5	-8.1
		$K_s$	-10.2	+12.7	+2.5
50 Fo	2.43	$L_s$	-13.1	+10.1	-3.0
		$\mu$	-16.8	+5.9	-10.9
		$K_s$	-11.0	+13.1	+2.1
100 Fa	2.40	$L_s$	-13.9	+10.2	-3.7
		$\mu$	-18.3	+3.4	-14.9
		$K_s$	-11.3	+14.1	+2.8

\*Geophysical literature concerned with the elasticity often assumes the elastic constants are a function only of volume, but this is clearly incorrect. Anderson & Nafe (1965, p. 3959) found a relationship between the shear modulus and volume for oxide compounds, but this correlation seen by these authors should be re-examined before being accepted. The elastic constants of most alkali halides in which there are prominent central forces between the constituent ions can be treated as a unique function of volume only, as was first demonstrated by Lazarus (1949). A direct translation of this picture of the alkali halides to the system of oxides and silicates is dangerous and often misleading.