4. Elastic properties of olivine

4.1. *Variation with pressure*

Table 1 summarizes the primary data obtained from the ultrasonic-pressure experiments for all the olivine samples considered in the present study; an estimated total uncertainty in P and S velocities is indicated. This uncertainty includes estimated experimental errors and variations in velocities due to an apparent anisotropy of the olivine sample. The apparent anisotropy of each sample was observed to be small, possibly due to the method of sample preparation (see Cl, p. 7354). The uncertainty in the values of $(f_{jp}/f_{j0})^2$ corresponds to the standard deviation from the weighted least square fit to the experimental data. Fig. 1 shows a variation of $(f_{jp}/f_{j0})^2$ with pressure for olivines by varying the Fe/(Mg+Fe) ratio. It is seen here that the iron substitution for magnesium in the olivine lattice is more sensitive to the pressure variation of S waves than for P waves. From the experimental data in Table 1 applied to the procedure described in the earlier section, values of the first pressure derivative of the elastic constants for various olivines are found. These values are tabulated in Table 2. Also entered in Table 2 are the pressure derivatives of both P and S velocities which were calculated in the usual way. Fig. 2 shows a variation of the pressure coefficients of P and S velocities for olivine as a function of molar percentage fayalite in olivine. Using the criteria defined by Chung (1968, p. 417), these pressure coefficients of the elastic constants should hold to pressures of about $0{\cdot}1\ K_T$ (thus corresponding to a depth of about 360 km); any further extrapolation is unjustifiable.

The pressure coefficient of P velocity changes very little with the iron substitution for magnesium in the olivine lattice. As seen in Fig. 2, the coefficient varies linearly from $1{\cdot}2\ \mathrm{mb}^{-1}$ for forsterite to $1{\cdot}33\ \mathrm{mb}^{-1}$ for fayalite. The iron substitution for magnesium significantly affected the pressure coefficient of the S velocity. The coefficient is $0{\cdot}8\ \mathrm{mb}^{-1}$ for forsterite, and for fayalite it becomes about $0{\cdot}2\ \mathrm{mb}^{-1}$. This variation with increasing iron content is greater than that assumed in many geophysical discussions of the mantle. The apparent reduction in the value of $(d\ \ln V_s/dp)$ of about

Table 1

Composition and measured properties of various olivine samples from ultrasonic-pressure experiments (at 296° K)

Olivine composition, mole (%)	Sample density, g cm^{-3}	Porosity, (%)	Compressional velocity, V_p, km s^{-1}	Shear velocity, V_s, km s^{-1}	$(f_p/f_{p0})^2$ (evaluated at 10 kb)	$(f_s/f_{s0})^2$ (evaluated at 10 kb)
100 Fo	3·164	1·65	8·459 (±·040)	4·938 (±·018)	1·02941 (±·00017)	1·02059 (±·00010)
95 Fo	3·176	2·98	8·287 (±·046)	4·823 (±·020)	1·02965 (±·00021)	1·02051 (±·00011)
90 Fo	3·270	1·90	8·226 (±·033)	4·769 (±·019)	1·03004 (±·00018)	1·02066 (±·00011)
85 Fo	3·386	2·83	8·088 (±·047)	4·676 (±·018)	1·03005 (±·00019)	1·02046 (±·00011)
80 Fo	3·365	2·19	8·017 (±·039)	4·615 (±·016)	1·03009 (±·00016)	1·01929 (±·00010)
50 Fo	3·732	1·80	7·454 (±·037)	4·178 (±·017)	1·03079 (±·00019)	1·01681 (±·00012)
100 Fa	4·287	2·41	6·502 (±·033)	3·421 (±·015)	1·03212 (±·00018)	1·00982 (±·00012)

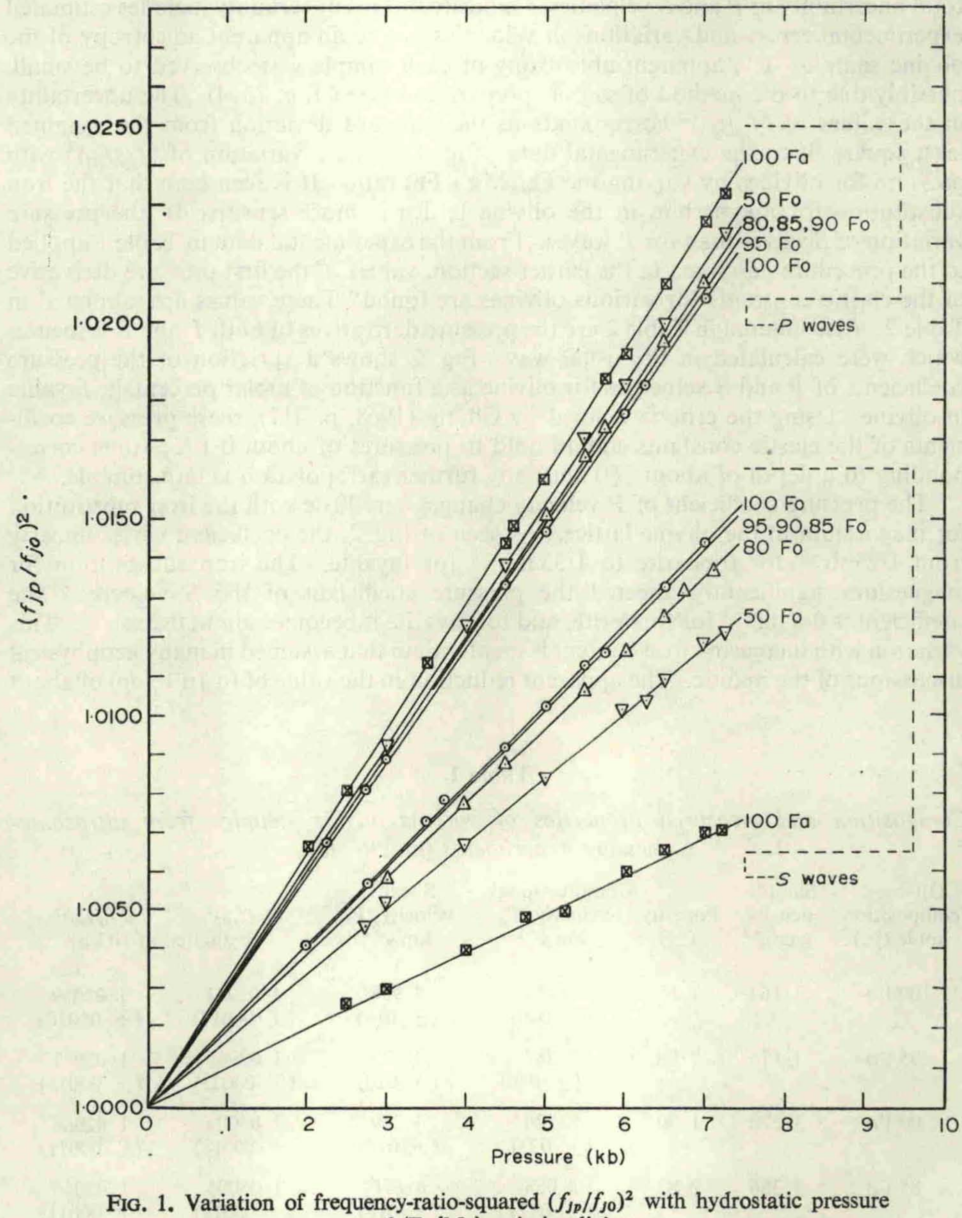

FIG. 1. Variation of frequency-ratio-squared $(f_{jp}/f_{j0})^2$ with hydrostatic pressure and (Fe/Mg) ratio in olivine.