

For olivine, this correction is found to be small, as compared with experimental errors involved in the K_0 and m values, and is therefore neglected for present purposes.

The calculated volume-pressure trajectories for 100Fo and 100Fa olivines are compared with compression data in Fig. 8. The compression data entered here are those of Bridgman, Takahashi, and McQueen *et al.*; it is seen that the trajectories compare very well with these compression data.

5.2. Variation with temperature

Pressure increases the density of olivine, but temperature reduces it; thus there is a critical pressure p_{cr} defined by the pressure, for a given temperature, at which

$$\rho(p_{cr}, T) = \rho(p = 0, T = RT)$$

RT refers to an ambient reference temperature. At p_{cr} , temperature effects on density cancel the pressure effects completely. Below p_{cr} , temperature effects on the density dominate over the pressure effects, and above p_{cr} the pressure effects dominate over the temperature effects on the density of the solid. This critical pressure for olivines with different $\text{Fe}/(\text{Mg} + \text{Fe})$ ratios can be estimated from data on thermal expansion and compression ratio resulting from the equation of state (10) by

$$p_{cr}(T) = K_T(T)\{(p/K_0)\} \quad \text{at } \rho_0/\rho(T). \quad (11)$$

Values of the critical pressure for olivine at three chosen temperatures (700° , 1000° and 1700°K) are listed in Table 7. For example, at 1000°K , p_{cr} for forsterite is about 34 kb and about 26 kb for fayalite.

The Birch equation of state is isothermal referring to the compression ratio $\rho(p, T)/\rho(p = 0, T = RT)$ and $K_0(p = 0, T)$. Suppose, however, we wish to relate all our compression data to the ambient conditions. Then, in accordance with the procedure described earlier (see CWS, p. 5119), we have

$$\frac{\rho(p, T)}{\rho(p = 0, T = RT)} = \frac{\rho(p, T)}{\rho(p = 0, T)} \cdot \frac{\rho(p = 0, T)}{\rho(p = 0, T = RT)} \quad (12)$$

under the assumption that the density ratio given by $\rho(p = 0, T)/\rho(p = 0, T = RT)$ is independent of pressure. (This assumption is a practical one and a good approxima-

Table 7

Relative density and 'Critical' pressure of olivine at three different temperatures

Property†	Temperature,		Olivine composition, mole %					Probable error,
	°K		100 Fo	90 Fo	80 Fo	50 Fo	100 Fa	%
$\rho(p, T)/\rho_0$	700	0.9852	0.9853	0.9861	0.9872	0.9883		1
	1000	0.9732	0.9740	0.9744	0.9763	0.9789		1
	1700	0.9440	0.9450	0.9462	0.9500	0.9560		3
p_{cr} , kb	700	19.5	19.4	18.1	16.7	15.1		2
	1000	33.7	32.5	32.3	29.8	25.6		2
	1700	69.5	67.5	65.2	60.1	51.4		5

† The critical pressure referred here to as p_{cr} is defined as the pressure, for a given temperature, at which $\rho(p_{cr}, T) = \rho(0, 296^\circ\text{K})$, and is meant to imply the following: Pressure works in the opposite direction of temperature, but at p_{cr} temperature effects cancel the pressure effects on density. Above this p_{cr} , the pressure effects dominate over the temperature effects in solid.

tion, since a factor of three change in thermal expansion changes the density ratio by less than 1 per cent.) Thus we can obtain $\rho(p, T)/\rho(p=0, T=RT)$ by multiplying the isothermal compression ratio $\rho(p, T)/\rho(p=0, T)$ by the constant factor $\rho(p=0, T)/\rho(p=0, T=RT)$ obtained from thermal expansion data. The results on two chosen temperatures (1000° and 1700° K) are plotted in Fig. 7. Fig. 7 shows the pressure-dependent density of olivine as a function of temperature and Fe/(Mg+Fe) ratio. It is generally seen that olivines of all the compositions are more compressible at high temperatures. It is also seen that the greater the Fe/(Mg+Fe) ratio in olivine the more compressible the olivine becomes at all temperatures.

6. Application to the Earth

The elasticity data presented in this paper may aid discussion of the Earth's mantle within a peridotitic model. We have attempted to relate the elasticity data with the bulk sound velocity and density distribution in the Earth's mantle. As noted by Pree (1970b), a comparison of laboratory data with velocity-density distribution of earth models minimizes the errors arising from uncertain temperature distributions in the Earth's interior.

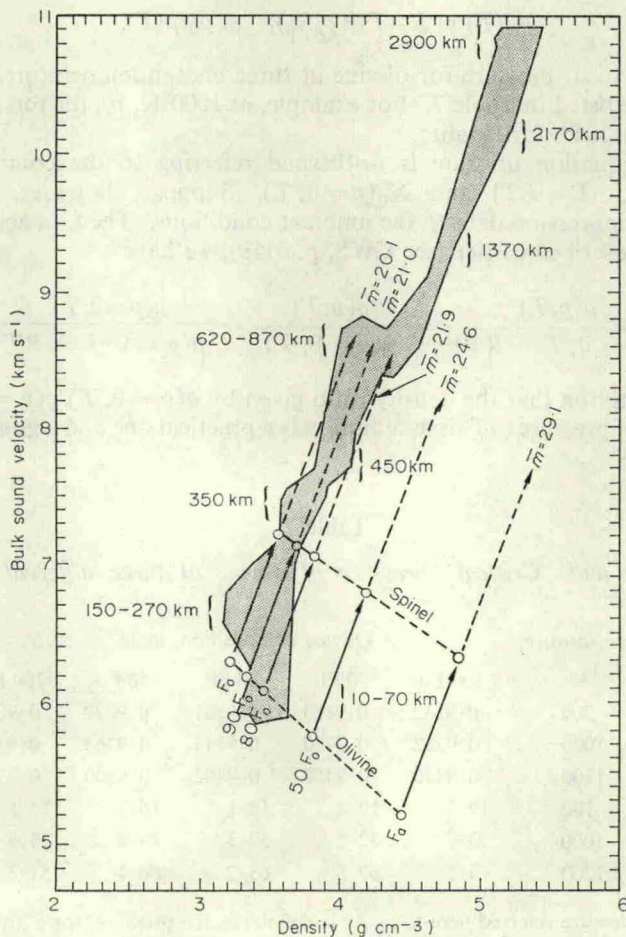


FIG. 9. Comparison of the laboratory V_ϕ - ρ relation for olivine with F. Press's solutions of the Earth data.