

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 ( $700^\circ$ ,  $1000^\circ$  and  $1700^\circ\text{K}$ ) are listed in Table 7. For example, at  $1000^\circ\text{K}$ ,  $p_{cr}$  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.

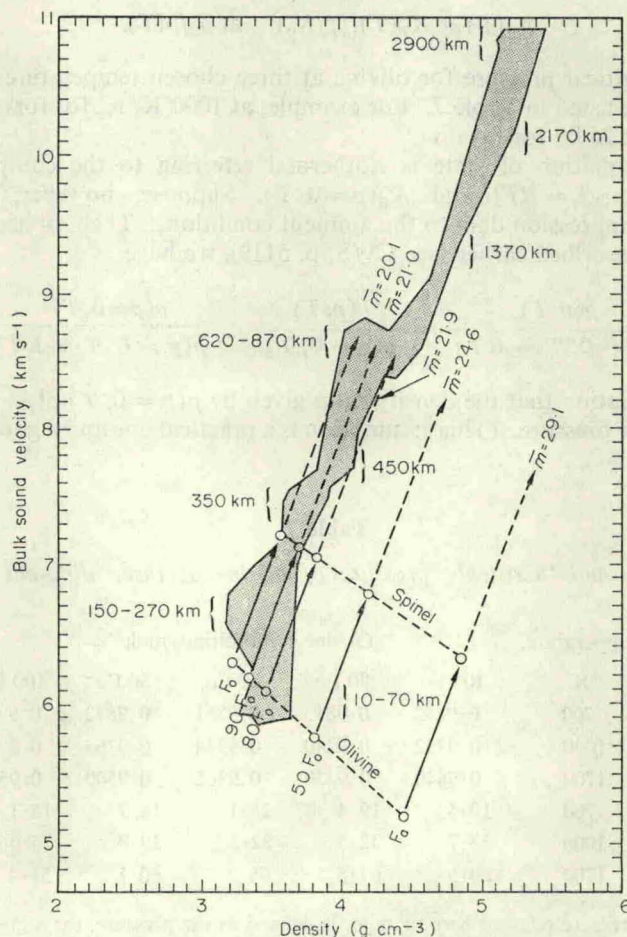


FIG. 9. Comparison of the laboratory  $V_\rho$ - $\rho$  relation for olivine with F. Press's solutions of the Earth data.