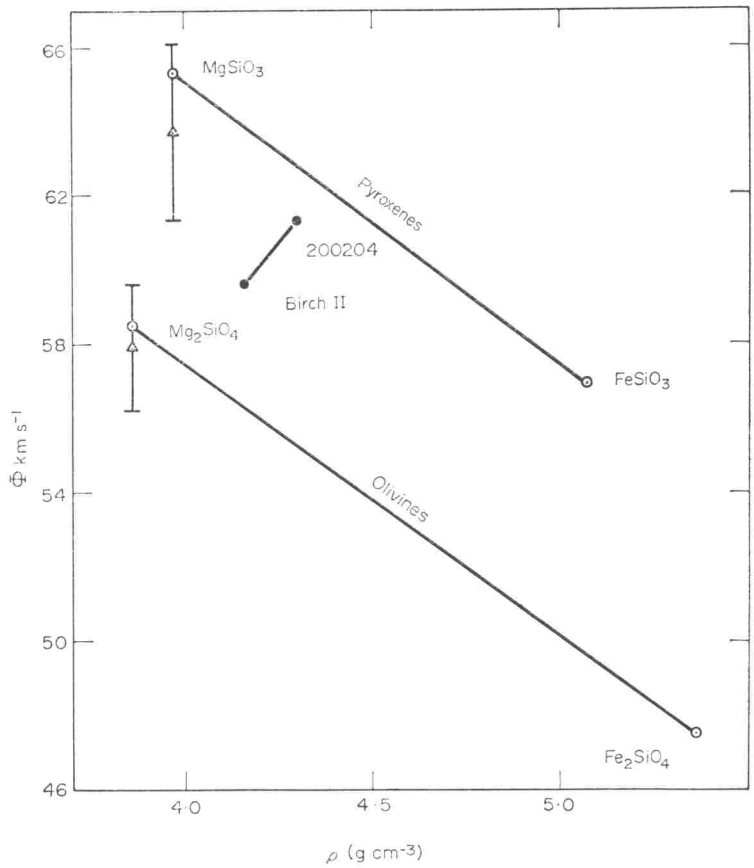

FIG. 7. Molar averaging scheme for estimating composition of the lower mantle from Φ_0 and ρ_0 values of olivine and pyroxene based on isochemical mixtures of the oxides FeO, MgO, and SiO_2 (after Anderson & Jordan 1970).

The results of the present review indicate ranges in oxide content for the two models of 47–53 mole per cent SiO_2, 26–38 mole per cent MgO, and 15–21 mole per cent FeO. The estimated uncertainties are indicated also in Table 2. When compared with the corresponding values for ultramafic rocks (White 1967) of 38 per cent SiO_2, 52 per cent MgO, and 6 per cent $FeO+\frac{1}{2}Fe_2O_3$, these results are consistent with those of Anderson & Jordan (1970) and Anderson (1970) in suggesting that the lower mantle is enriched in FeO and SiO_2 relative to the upper mantle. These results assume, of course, that the $\rho_0-\Phi_0$ points represented by the Birch II and 200204 models are representative of lower mantle material properties. In this regard, an uncertainty of ± 10 per cent in the values of Φ_0 still allows marginal recognition of the basic conclusions of Anderson & Jordan (1970). However, the possible inaccuracy in the model values of ρ_0 is not clear. Uncertainty in the calculated value of the initial ambient density for the lower mantle can arise from several sources: vertical inhomogeneity in lower mantle assemblages; a super-adiabatic temperature gradient; use of an inappropriate equation of state; and, inaccuracy associated with the selected density distribution. For example, considering the latter source only in terms of the results of Anderson & Jordan (1970), satisfactory fits were obtained for a number of density distributions yielding a range of values for ρ_0 of 4·08 (Birch I) to 4·30 (200204). This corresponds to a range in iron content of 6–21 mole per cent FeO. Thus, again, consideration of the uncertainties involved indicates iron enrichment of the lower mantle, but the evidence is marginal.

The present analysis, emphasizing the uncertainties in the equation of state and elastic properties of stishovite, suggests that the conclusions of Anderson & Jordan (1970) and Anderson (1970) concerning iron enrichment in the lower mantle are plausible within the accuracy of the material property data. Basic assumptions regarding homogeneity, temperature gradient, and density in terms of an isochemical mixture of oxides remain to be verified. In this regard, it should be emphasized that the preceding evaluation and conclusions are relevant to the explicit assumption that the lower mantle can be represented by a mixture of the component oxides, MgO, FeO, and SiO_2 only. Granting this supposition, it is reasonable to conclude that the most probable solution indicates an increase in FeO/FeO+MgO relative to the upper mantle, although this is not strictly required if the full uncertainty range is considered. An evaluation of the alternative suggestion, that the elastic properties of the lower mantle reflect phases involving more closely-packed structures than the component oxides (i.e. Ringwood 1968), is obviously not possible with the present set of material property data.

Acknowledgments

The author is grateful for suggestions and comments concerning various aspects of this work by C. G. Sammis and R. J. Greenfield. In addition, preprints of work to be published were kindly provided by G. F. Davies, H. Mitzutani, and H. Wang. A review of the manuscript and several helpful suggestions were provided by A. E. Ringwood. The data reduction was carried out by the Computation Center of The Pennsylvania State University.

Department of Geosciences,
The Pennsylvania State University,
University Park, Pennsylvania 16802.

References

Ahrens, T. J., Anderson, D. L. & Ringwood A. E., 1969. Equations of state and crystal structure of high-pressure phases of shocked silicates and oxides, *Rev. Geophys. Space Phys.*, **7**, 667–707.

Ahrens, T. J., Takahashi, T. & Davies G. F., 1970, A proposed equation of state of stishovite, *J. geophys. Res.*, **75**, 310–316.

Al'tshuler, L. V., Trunin R. F. & Simakov, G. V., 1965, Shock-wave compression of periclase and quartz and the composition of the Earth's lower mantle, *Izv. Earth Phys. Ser.*, **No. 10**, 1–6.

Anderson, Don L., 1967. A seismic equation of state, *Geophys. J. R. astr. Soc.*, **13**, 9–30.

Anderson, Don L., 1969. Bulk modulus–density systematics, *J. geophys. Res.*, **74**, 3857–3864.

Anderson, Don L., 1970. Petrology of the mantle, *Mineral. Soc. Am. Spec. Pap.*, **3**, 85–93.

Anderson, Don L. & Anderson, O. L., 1970. The bulk modulus–volume relationship for oxides, *J. geophys. Res.*, **75**, 3494–3500.

Anderson, Don L. & Jordan, T., 1970. The composition of the lower mantle, *Phys. Earth Planet. Int.*, **3**, 23–35.

Anderson, Don L. & Kanamori, H., 1968. Shock-wave equations of state for rocks and minerals, *J. geophys. Res.*, **73**, 6477–6502.

Anderson, Don L., Sammis, C. & Jordan, T., 1971. Composition and evolution of the mantle and core, *Science*, **171**, 1103–1112.