In recent years, precise data on travel times for *P* and *S* waves, the spatial derivatives of these travel times, the equally accurate eigenperiods of the Earth, as well as surface wave dispersion, have become available (see, for example, Archambeau, Flinn & Lambert (1969), Whitcomb & D. L. Anderson (1970), and Kanamori (1970). The usefulness of these geophysical data has initiated numerous data inversions to obtain the unique elastic wave velocity and density distribution in the Earth. Among the more successful methods are the Monte Carlo techniques to develop families of possible solutions for the entire Earth. Press (1968, 1969, 1970a, b) presented a systematic development of these Monte Carlo solutions and established workable contraints for the earth models. Press (1970b) recently derived successful models for density and elastic wave velocity distributions in the Earth, using oceanic data.

The Monte Carlo solutions for the bulk sound velocity-density relation of the Earth's mantle, presented by Press (1970b), is reproduced in Fig. 9. Fig. 9 compares the density and bulk sound velocities found in this work with Press's solutions. In terms of Press's division of the mantle into three zones, we find for the second zone that the slopes of olivine and olive-transformed spinel with Fe/(Mg+Fe) ratios of about 0·05 to 0·15 are quite similar to large numbers of the Monte Carlo successful solutions in the region 150–870 km. These Fe/(Mg+Fe) ratios correspond to the mean atomic weight $\overline{m}$ of about 20·1 to 21·5 agreeing with the $\overline{m}$ limit set by Press. The olivine-spinel phase change at about 350 km is indicated in the velocity-density plot; the laboratory data on the bulk sound velocity-density plot are in accordance with the result of the Monte Carlo solutions.

If one accepts the present elasticity data as representative of olivine, one must then conclude, within the framework of a peridotitic model, that the olivine has the necessary equation-of-state properties to qualify as a likely candidate for mantle constituents.

Acknowledgments

The author expresses his thanks to Dr Frank Press for discussion and interest shown in this work. I am grateful to Dr Gene Simmons for encouragement and the use of capital equipments.

Financial support of this work was provided by the National Science Foundation Grant GA-11091, which the author gratefully acknowledges.

Department of Earth & Planetary Sciences,
Massachusetts Institute of Technology,
MIT *Room* 54-716
Cambridge, Massachusetts 02139

References

Adams, L. H., 1931. The compressibility of fayalite, and the velocity of elastic waves in peridotite with different iron-magnesium ratio, *Beitr. Z. Geophys.*, **31,** 315–321.

Ahrens, T. J., Lower, J. H., & Lagus, P. L., 1971. Equation of state of forsterite, *J. geophys. Res.*, **76,** 518–528.

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

Anderson, O. L. & Nafe, J. E., 1965. The bulk modulus-volume relationship for oxide compounds and related geophysical problems, *J. geophys. Res.*, **70,** 3951–3963.

Anderson, O. L., Schreiber, E., Liebermann, R. C. & Soga, N., 1968. Some elastic constant data on minerals relevant to geophysics, *Rev. Geophys.*, **6,** 491–524.

Archambeau, C. B., Flinn, E. A. & Lambert, D. G., 1969. Fine structure of the upper mantle, *J. geophys. Res.*, **74,** 5825–5865.

Bacon, R. H., 1953. The " best " straight line among the points, *Am. J. Phys.*, **21,** 428–446.

Birch, F., 1952. Elasticity and constitution of the Earth's interior, *J. geophys. Res.*, **57,** 227–286.

Birch, F., 1960. The velocity of compressional waves in rocks to 10 kb, Part 1, *J. geophys. Res.*, **65,** 1083–1102.

Birch, F., 1961a. The velocity of compressional waves in rocks to 10 kb, Part 2, *J. geophys. Res.*, **66,** 2199–2224.

Birch, F., 1961b. Composition of the Earth's mantle, *Geophys. J. R. astr. Soc.*, **4,** 295–311.

Birch, F., 1969. Density and composition of the upper mantle: First approximation as an olivine layer, in *The Earth's Crust and Upper Mantle*, edited by P. J. Hart. Geophysical Monograph No. 13, American Geophysical Union, Washington, D.C.

Brace, W. F., 1965. Some new measurements of linear compressibility of rocks, *J. geophys. Res.*, **70,** 391–398.

Brace, W. F., Scholz, C. H. & LaMori, P. N., 1969. Isothermal compressibility of kyanite, andalusite, and sillimanite from synthetic aggregates, *J. geophys. Res.*, **74,** 2089–2098.

Bridgman, P. W., 1948. Rough compression of 177 substances to 40,000 kg/cm^3, *Proc. Am. Acad. Arts Sci.*, **76,** 71–87.

Chung, D. H., 1968. The elastic constants of a cubic crystal subjected to moderately high hydrostatic pressure, *J. Phys. Chem. Solids*, **29,** 417–422.

Chung, D. H., 1970. Effects of iron/magnesium ratio on *P*- and *S*-wave velocities in olivine, *J. geophys. Res.*, **75,** 7353–7361.

Chung, D. H., 1971a. Pressure coefficients of elastic constants for porous materials: Correction for porosity and discussion of literature data, *Earth Planet. Sci. Letters*, **10,** 316–324.

Chung, D. H., 1971b. Equations of state of olivine-transformed spinels in the Mg_2SiO_4-Fe_2SiO_4 system, submitted to *Earth Planet. Sci. Letters.*

Chung, D. H., Wang, H. & Simmons, G., 1970. On the calculation of the seismic parameter ϕ at high pressure and high temperatures, *J. geophys. Res.*, **75,** 5113–5120.

Christensen, N. I., 1966a. Shear wave velocities in metamorphic rocks at pressures to 10 kbar, *J. geophys. Res.*, **70,** 3549–3556.

Christensen, N. I., 1966b. Elasticity of ultrabasic rocks, *J. geophys. Res.*, **71,** 5921–5931.

Christensen, N. I., 1968. Chemical changes associated with the upper mantle structure, *Tectonophysics*, **6,** 331–342.

Dow Chemical Company, 1960. *JANAF Thermochemical Data*, Midland, Michigan.

Fujisawa, H., 1970. Elastic properties of polycrystalline olivine, *Trans, A.G.U.*, **51,** 418. (Abstract only).

Graham, E. K., 1970. Elasticity and composition of the upper mantle, *Geophys. J. R. astr. Soc.*, **20,** 285–302.

Graham, E. K. & Barsch, G. R., 1969. Elastic constants of single-crystal forsterite as a function of temperature and pressure, *J. geophys. Res.*, **74,** 5949–5960.

Kanamori, H., 1970. Velocity and Q of mantle waves, *Phys. Earth Planet. Int.*, **2,** 259–266.

Kanamori, H. & Mizutani, H., 1965. Ultrasonic measurement of elastic constants of rocks under high pressures, *Bull. Earthquake Res. Inst.* (*Tokyo*), **43,** 173–194.

Knopoff, L., 1967. Density-velocity relations for rocks, *Geophys. J. R. astr. Soc.*, **13,** 1–8.