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PRESSURE COEFFICIENTS OF ELASTIC CONSTANTS FOR POROUS MATERIALS: CORRECTION FOR POROSITY AND DISCUSSION ON LITERATURE DATA

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An empirical scheme, by which one can correct porosity effects on pressure coefficients of elastic constants for porous materials, is presented. The underlying idea for the scheme is our recognition of experimental observations that the rate of change of ultrasonic transit-times with hydrostatic pressure in a porous medium is independent of small porosity at a pressure range of 2 to 10 kb, a range of pressure most commonly utilized in acoustic experiments. The scheme has been successfully tested with two polycrystalline forsterite samples of 1.65% and 6.09% porosities, two polycrystalline corundum samples with about 0.3% porosity each, and one polycrystalline rutile sample with 0.89% porosity, for all of which the corresponding single-crystal data are available. In the light of the present work, most of the elasticity data obtained on polycrystalline samples may require revision; for example, the literature value of dK_s/dp for hematite with 0.4% porosity is 4.53, which after the porosity correction becomes 4.91, while dK_s/dp reported as 4.80 for a forsterite sample with 6.09% porosity becomes 5.19 with the porosity correction. It is concluded that the scheme presented here may be useful as a working tool for experimentalists dealing with the elasticity of polycrystalline materials.

1. Introduction

One of the more important objectives of geophysics is to transform, uniquely, the elasticity of the Earth into parameters of composition, pressure, and temperature of earth materials. Accurate data on these equation-of-state parameters measured in the laboratory on carefully characterized minerals and rocks are therefore essential in the interpretation of geophysical field-data as well as in our understanding of solid state properties of these materials. Laboratory measurements of these data can be made either on single-crystals or on dense-formed polycrystalline samples. The frequent limitation of the unavailability of single-crystal specimens large enough for acoustic measurements to be made upon them hinders the laboratory determination of these data.

With advances in ceramic fabrication process (see, for example, Crandall et al. [1]), some polycrystalline aggregates can be fabricated into quasi-isotropic bodies with a density comparable to the single-crystal density*. Clearly, however, most polycrystalline

* Since the writer's success in 1961 in hot-pressing corundum samples with small porosities and the subsequent correlation for a correspondence between single-crystal and polycrystalline elastic properties (Chung [2] and see also Anderson [3, p. 912; 4, p. 491]) much progress has been made regarding the elasticity of polycrystalline oxides and silicates. O.L. Anderson and his associates at Lamont-Doherty Geological Observatory made use of this idea extensively (see, for example, ref. [19] for a summary). The following examples in chronological order of development may be listed: (a) *periclase* with about 0.1% porosity, see Chung [5, 33], Anderson [4, p. 51], and Anderson and Schreiber [6, 34]; (b) *spinels* with about 1% porosity, see Chung et al. [7]; (c) *forsterite* with 6.09%, see Schreiber and Anderson [8]; (d) *zincite* with about 1% porosity, see Chung and Buessem [9], and also Soga and Anderson [10]; (e) *lime* with 1.8% porosity, see Soga [11]; (f) *hematite* with 0.4% porosity, see Liebermann and Schreiber [12]; (g) *rutile* with 0.89% porosity, see Chung and Simmons [13]; (h) *quartz* with 0.15% porosity, see Chung and Simmons [13]; (i) *olivine* of various (Fe/Mg) ratios, see Chung [14]; (j) *fayalite* with about 2.5% porosity, see Fujisawa [15] and Chung [14]; (k) (Fe_2SiO_4) *spinel*, see Mizutani et al. [16].