

Table 3  
Isotropic elastic properties of rutile.

Sample property	Unit	Polycrystalline data*		Single-crystal data**
		Porous	Nonporous	
$\rho$	g/cm <sup>3</sup>	4.212	4.250	4.260
$V_p$	km/sec	9.146	<u>9.193</u>	9.261
$V_S$	km/sec	5.102	<u>5.122</u>	5.137
$\phi$	(km/sec) <sup>2</sup>	48.96	<u>49.53</u>	50.59
$\sigma_S$	none	0.264	<u>0.274</u>	0.272
$L_S$	kb	3524	<u>3592</u>	3654
$\mu$	kb	1096	<u>1115</u>	1124
$K_S$	kb	2062	<u>2105</u>	2155
$dL_S/dp$	none	7.57	<u>7.7</u>	7.80
$d\mu/dp$	none	0.91	<u>0.9</u>	0.78
$dK_S/dp$	none	6.35	<u>6.4</u>	6.76
$R_p$	per kb	0.001984		—
$R_S$	per kb	0.000679		—

\* Data from Chung and Simmons [13].

\*\* VHR values based on single-crystal data reported by Manghani [31].

will not be used in the present discussion. Table 3 presents the acoustic data obtained on a rutile sample with 0.89% porosity. The porosity-correction has been made to these data, and they are compared in the table with the corresponding data of gem-quality rutile single-crystals [31]. The comparison between the porosity-corrected polycrystalline data and the single-crystal data is generally satisfactory.

#### 4. Discussion and conclusion

Examples with forsterite, corundum, and rutile given above indicate that the scheme presented in this paper seems to correct porosity effects on the pressure derivatives of the elastic constants of porous materials.

One-fourth of the volume of this sample was pores; with application of pressure, the pressure medium (petroleum ether in this case) undoubtedly penetrates into the pores. The property measured in such a sample is then some property of a "solid-liquid" composite under the pressure. Examination of the original data (see [13], p. 136) reveals that the shear waves were more critically affected.

Validity of the proposed scheme is essentially established. The scheme could be a useful tool for experimentalists working with the elasticity of polycrystalline materials.

The elastic constants and their pressure derivatives of 10 compounds of interest to geophysical and geochemical theories have been tabulated by Anderson et al. [19]. Acoustic data on seven out of these ten compounds are based on porous polycrystalline samples they studied, in which the porosity ranges from 0.11% for periclase to 6.09% for forsterite. The writer applied the present scheme of correcting porosity effects to their acoustic data; the results are tabulated in table 4. Also entered in the table are the elasticity data by this writer for periclase, corundum, quartz, rutile, and forsterite. Effect of the porosity correction is generally small. Most severely affected quantities are  $d\mu/dp$  and  $dK_S/dp$  for hematite (with 0.4% porosity) and forsterite (with 6.09%). The  $dK_S/dp$  value as reported originally by Liebermann and Schreiber [12] for hematite is 4.53, which after the porosity correction becomes 4.91, while  $dK_S/dp$ , reported originally as 4.80 by Schreiber and Anderson [8] for their for-

Table 4  
Comparison of the elastic parameters before and after the porosity correction.

Material	Ref. *	Before correction						After correction				
		Density $\rho$ (g/cm <sup>3</sup> )	Porosity $\theta$ (%)	$\mu$ (kb)	$K_S$	$\frac{d\mu}{dp}$	$\frac{dK_S}{dp}$	$\rho_0$ (g/cm <sup>3</sup> )	$\mu^0$ (kb)	$K_S^0$	$\frac{d\mu^0}{dp}$	$\frac{dK_S^0}{dp}$
MgO	a, m	3.5797	0.11	1288	1624	2.62	4.58	3.583	1291	1627	2.74	4.43
MgO	b	3.582	0.03	1293	1644	2.41	4.28	3.583	1293	1644	2.41	4.28
CaO	c, m	3.285	0.30	761	1059	1.64	5.23	3.345	789	1099	1.69	5.42
ZnO	d, m	5.624	0.90	442	1394	-0.69	4.78	5.675	450	1437	-0.70	4.88
BeO	e, m	3.000	0.26	1618	2201	0.88	5.52	3.008	1626	2213	0.88	5.54
$\alpha$ -Al <sub>2</sub> O <sub>3</sub>	f, m	3.972	0.35	1613	2521	1.76	3.98	3.986	1624	2540	1.77	4.01
$\alpha$ -Al <sub>2</sub> O <sub>3</sub>	g	3.974	0.30	1616	2519	1.77	4.16	3.986	1632	2551	1.79	4.19
$\alpha$ -Fe <sub>2</sub> O <sub>3</sub>	h, m	5.2539	0.40	910	2066	0.73	4.53	5.274	917	2088	0.89	4.91
$\alpha$ -SiO <sub>2</sub>	i	2.645	0.15	446	377	0.47	6.53	2.649	447	378	0.5	6.5
TiO <sub>2</sub>	j	4.212	0.89	1096	2062	0.91	6.35	4.250	1115	2105	0.9	6.4
Mg <sub>2</sub> SiO <sub>4</sub>	k, m	3.021	6.09	574	974	1.30	4.80	3.217	614	1043	1.32	5.19
Mg <sub>2</sub> SiO <sub>4</sub>	l	3.164	1.65	772	1235	1.80	4.87	3.217	797	1281	1.85	5.04
Fe <sub>2</sub> SiO <sub>4</sub>	l	4.287	2.41	502	1144	0.64	5.49	4.393	536	1220	0.62	5.92

\* (a) Schreiber and Anderson [34].

(b) Chung and Simmons [33].

(c) Soga [11].

(d) Soga and Anderson [10].

(e) Soga [35].

(f) Schreiber and Anderson [29].

(g) Chung and Simmons [17].

(h) Liebermann and Schreiber [12].

(i) Chung and Simmons [13].

(j) Chung and Simmons [13].

(k) Schreiber and Anderson [8].

(l) Chung [26].

(m) Anderson et al. [19, table 1].

sterite sample, becomes 5.19 with the porosity correction. Furthermore, as is evident from table 4, the  $d\mu/dp$  value for hematite reported originally in [12] as 0.73 undergoes a 22% change with the porosity correction.

On the basis of their original experimental data obtained on ten model compounds, Anderson et al. [19, figs. 3 to 10] and Anderson and Liebermann [32] discussed patterns relating the elastic properties of oxides and silicates. Their extensive discussions were based on the *apparent* elastic properties of

various samples, including the seven porous polycrystalline specimens. *Any discussion of the general patterns relating the elastic properties requires the intrinsic properties of model solids characterizing the elasticity of those materials.* In view of table 4, then, all those correlations and patterns observed previously [19, 32] for the elastic properties of model oxides and silicates may have to be revised.

The conclusion of this paper is then that a more realistic establishment of the general patterns relating the elastic properties requires the *intrinsic* properties