

are hard to derive at present, as the experiments are only of limited accuracy, the range in K' being usually 3.5 - 4.5 (mean 4.0). Here we must note that the K from static methods differ from those obtained by dynamic methods, but the poor accuracy does not allow us to distinguish the adiabatic compressibility β_s from the isothermal value β_T .

This trend in K persists to higher P (up to a polymorphic transition to a denser modification, if there is one) [5, 9 - 14], though there is a tendency for K' to decrease as P increases. Shock-compression data [10 - 13] indicate that K' decreases discontinuously at the above transition point; for instance, the high P phases corresponding to quartz, spinel, magnetite, hematite, forsterite, fayalite, dunite, diabase, bronzitite, and plagioclase have [13] K' of 1 - 3.5 and average K' of 2.5 - 3.0, instead of the average 4.0 for low P . These are only preliminary values, since extrapolation via the Birch-Murnahan equation of state was used [12, 13] in calculating the zero parameters for the high-pressure phases. All the above minerals and rocks showed polymorphic transitions,

but none were detected for MgO , Al_2O_3 , and MnO_2 .

In spite of some spread in the values, pure substances give a fairly clear picture of the change in K with P . The picture is more complex for rocks and natural minerals, which may have grossly defective structures: K' is generally larger and varies nonlinearly with pressure, especially up to 2 - 5 kbar. The topic may be examined via the published data for wave speeds up to 10 kbar [5] and my own results up to 20 kbar [14, 27]. Table 3 summarizes the results for certain rock types, this being based on my recent results for wave speeds in igneous rocks from the Kola peninsula and for basalts of various types. Only for granites and dense fine-grained basalts does K' approach the theoretical value deduced from the corresponding minerals.

Little is known about $K(T)$ for oxides and silicates. The results are most complete for $\alpha - Al_2O_3$ from 4.2 to 1300° C at atmospheric pressure [15]: $\partial K_s / \partial T$ is -0.08 to -0.09 kbar/deg below 300° K, as against

Table 3
Changes in Bulk Modulus K , Young's Modulus E , and the Shear Modulus μ at High Pressures in Igneous Rocks

Rock	P range, kbar	Values at initial and final points				$\frac{\partial K_s}{\partial P}$	$\frac{\partial E}{\partial P}$	$\frac{\partial \mu}{\partial P}$
		ρ , g/cm ³	$K_s \cdot 10^{-5}$, kg/cm ²	$E \cdot 10^{-5}$, kg/cm ²	$\mu \cdot 10^{-5}$, kg/cm ²			
Olivinites	2-20	3.29-3.33	12.8-13.8	17.4-19.1	6.8-7.5	5.5	9.5	3.9
Bronzites	2-20	3.25-3.30	10.7-11.9	16.0-17.8	6.4-7.1	6.6	10.0	3.8
Harzburgites	2-20	3.30-3.34	11.9-13.3	17.0-18.7	6.8-7.4	7.7	9.4	3.3
Gabbro-norites	2-20	2.98-3.03	8.40-9.35	12.0-13.2	4.7-5.2	5.3	6.6	2.3
Pechenga diabase	2-20	3.05-3.12	8.0-8.95	11.0-12.1	4.3-4.7	5.0	6.1	2.2
Frederik diabase	2-10	3.03-3.05	8.3-9.0	11.1-11.6	4.3-4.6	9.1	6.8	2.5
Saint Reville diab.	2-10	2.98-3.01	8.12-8.66	10.5-11.1	4.1-4.4	6.7	7.5	3.4
Medium-grained dolerite	2-10	2.83-2.86	7.2-7.60	9.0-9.6	3.5-3.7	5.0	7.5	3.7
Fine-grained dolerite	2-20	2.96-3.03	7.60-8.35	10.2-11.0	3.9-4.34	4.2	4.5	2.8
Porous basalt	2-20	2.89-2.97	6.30-7.82	8.5-9.8	3.34-3.8	8.4	7.2	2.9
Fine-grained oceanic basalt	2-20	2.96-3.03	7.05-7.62	9.0-10.2	3.5-3.98	3.5	6.7	2.7
Granites	2-20	2.64-2.72	5.33-6.43	8.5-9.75	3.3-3.9	6.1	6.9	3.3