DAVI-G 73-

JUL 8 1974

VOL. 78, NO. 32 JOURNAL OF GEOPHYSICAL RESEARCH NOVEMBER 10, 1973

Measurement of Elastic Velocities of MgO under Shock Compression to 500 Kilobars

GEOFFREY F. DAVIES[1] AND THOMAS J. AHRENS

Seismological Laboratory, California Institute of Technology, Pasadena, California 91109

The velocities of rarefaction waves in shock-compressed MgO have been measured by observing the reduction of the shock front velocity near the sample edges due to the rarefaction waves propagating from the edges. The extent of this 'edge effect' is difficult to determine accurately because of its emergent nature. Arrangements sensitive to differences in shock front velocity yielded rarefaction wave velocities close to predicted longitudinal velocities in the high-pressure shock state. Velocities closer to the hydrodynamic sound speed in the shock state were obtained from less sensitive arrangements. These results can be interpreted in terms of a two-stage elastoplastic model of the decompression. The longitudinal velocities measured in shock states up to 528 kb imply second pressure derivatives of the elastic moduli c_{ij}'', given by $K_0c_{ij}'' = -1 \pm 15$, where K is the bulk modulus.

The measurement of the velocities of rarefaction waves that propagate into shock-compressed materials provides a method for directly determining the elastic properties of the material in the high-pressure shock state. Direct measurement of the elastic moduli of solids, using ultrasonic techniques, have to date been made only to pressures of about 20 kb. At higher pressures, information about elasticity is usually obtained from pressure-density curves determined by static compression X ray, piston cylinder measurements, or from shock wave Hugoniot data. These determinations yield only one elastic modulus, the bulk modulus, and considerable accuracy is lost because the derivative of the pressure-density data has to be taken. Alternative, more direct methods of determining the elastic moduli are therefore potentially very useful. Initial results are reported here of measurements of rarefaction wave velocities in MgO shock-compressed to over 500 kb.

EXPERIMENTAL TECHNIQUE

The method used in this study consists of measuring the extent of the rarefaction that propagates into the shock region from the sides of the sample. Such a method was applied by *Al'tshuler et al.* [1960] to the study of some metals. The configuration of the sample and the waves is shown in Figure 1. The shock wave is generated at the lower surface of the sample as a result of the impact of a projectile whose velocity is measured just prior to impact [*Ahrens et al.*, 1971]. As the shock wave propagates through the sample, rarefactions propagate inward from the unconstrained (zero pressure) sides of the sample, reducing the shock pressure and hence reducing the velocity of the shock front near the edge of the sample. The combined lower shock velocity and lower pressure give rise to a lower free surface velocity near the sample edges when the shock front reaches the top sample surface. A mirror is placed a small distance above the sample with the silvered surface facing the sample, and the impact of the sample onto the mirror is recorded by viewing the mirror through a slit, the image of which is streak-recorded by an image converter camera (Figure 2) [*Ahrens et al.*, 1971]. Typical records are shown in Figure 3. The cutoff of the film streak, schematically illustrated in Figure 2, occurs first in the central part, corresponding to that part of the shock front unaffected by lateral rarefactions. The cutoff then occurs progressively further toward the edges of the sample as the slower moving free surface nearer the edges reaches the mirror. The extent of the edge effect is determined by measuring the central linear portion of the cutoff.

[1] Now at the Hoffman Laboratories, Harvard University, Cambridge, Massachusetts 02138.

Copyright © 1973 by the American Geophysical Union.