of the garnet equation of state. This high compression represents the onset of a mixed garnet–garnet hpp transition zone, which persists to approximately 300 kb.

Above 300 kb and up to the highest pressures attained in this study (slightly over 650 kb) the Hugoniot data are characterized by a fairly constant offset below the garnet equation-of-state trajectories. This region probably represents the Hugoniot of the homogeneous high-pressure phase. Examination of the offset suggests a density increase of approximately 5% between the garnet and garnet hpp phases. Considerable effort is made in later sections to infer the probable structure and the elastic properties of the high-pressure phase.

On all shots with a final pressure less than 470 ± 40 kb a double-wave structure was observed. The initial shock wave was characterized by velocities between 8.20 and 9.07 km/sec and amplitudes between 57 and 140 kb. However, the average velocity, 8.5 ± 0.2 km/sec, is consistent with the elastic compressional wave velocity, 8.52 ± 0.01 km/sec, which was measured for the garnet sample in the [100] direction by using acoustic interferometry. Compressional wave velocities were measured on four of the oriented Salida garnet target blanks (Al-4, Al-7, Al-9, and Al-12) prior to the shock experiment. A modified phase comparison technique [*Spetzler,* 1970] over a frequency range 10–30 MHz was used in the measurements. The average value, indicated previously, yields a value of 3040 ± 15 kb for C_{11}^S, the adiabatic second-order elastic coefficient for almandine-garnet. This value is consistent with the C_{11}^S

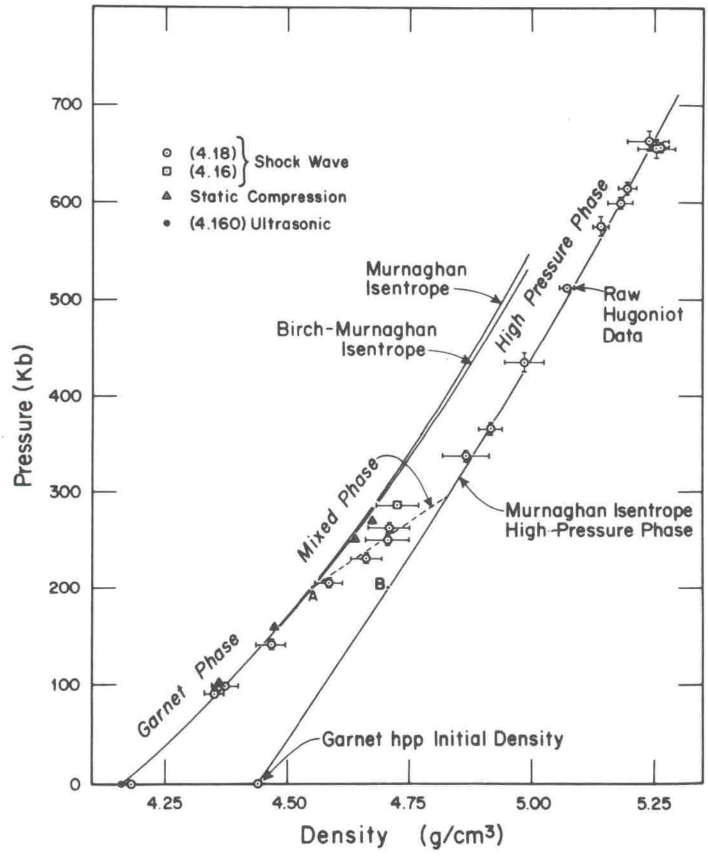

Fig. 4. The final Hugoniot compression states reached in the shock wave experiments. Ultrasonic data [*Soga,* 1967] and isothermal compression data [*Takahashi and Liu,* 1970] for an almandine-garnet specimen of composition similar to that of the present study are indicated for comparison.

value measured by *Soga* [1967]. Therefore the initial low-pressure wave appears to represent an elastic precursor, a one-dimensional compression wave in which internal rearrangement of the garnet sample has not yet taken place.

The final Hugoniot states have also been determined in the shock velocity–particle velocity plane (Figure 5). However, when a double shock front occurs, as it does in the present situation, the measured shock velocity values (Table 1) reflect the interaction of the second wave with the reflection of the elastic precursor off the free surface. Therefore the 'effective' shock velocities [*Wackerle,* 1962] have been calculated according to

$$U_s^* = [\rho P_H/\rho_0(\rho - \rho_0)]^{1/2} \tag{1}$$

and

$$u_p^* = [P_H(\rho - \rho_0)/\rho\rho_0]^{1/2} \tag{2}$$

where P_H and ρ represent points along the measured Hugoniot. These represent the true shock and particle velocities at pressures high enough that the 'second' wave is the only wave in the shock process. The ranges of the various phases, corresponding to the density-pressure representation in Figure 4, are also indicated in Figure 5.

INITIAL DENSITY OF HIGH-PRESSURE PHASE

Reducing the shock Hugoniot data of the high-pressure phase involves the recovery of three important material properties: the zero pressure density ρ_0, the isentropic bulk modulus K_0^S, and the isothermal pressure derivative of the isentropic bulk modulus $(\partial K_0^S/\partial P)_T$. However, regardless of the methodology chosen for reducing the measured raw Hugoniot data, it has been pointed out by *McQueen et al.* [1967, p. 5020] that, although there is a combination of the above unknown parameters '. . . that gives the best fit, the experimental data are usually not good enough to warrant this selection. However, the data do appear good enough to determine two of the parameters if the third is specified.' Consequently, various investigators have sought to constrain one or more of the unknown parameters to calculate the others. The usual method is to determine the zero pressure density ρ_0 of the unknown high-pressure phase by using various empirical relations involving bulk modulus–density systematics of similar materials [e.g., *Anderson and Kanamori,*

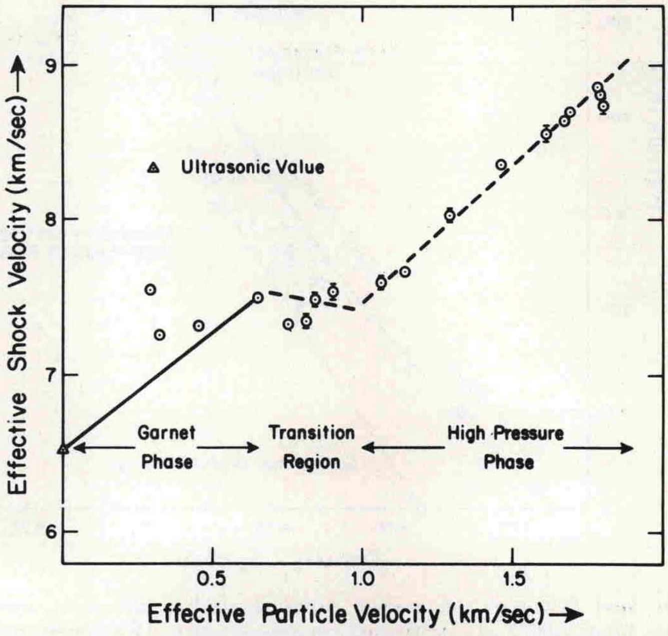

Fig. 5. Effective shock velocity–particle velocity representation. The various phase regimes are indicated, as is the acoustic value of *Soga* [1967].