III. PHASE TRANSITIONS

3.1 Introduction

Solid-solid phase transitions are classified as first order if a volume discontinuity exists at constant temperature and as second or higher order if discontinuities exist only in various thermodynamic derivatives. We are concerned here only with first order changes. If such a change occurs reversibly, the transition region is characterized by the equality of the Gibbs energies of the two phases. This leads to the Clausius-Clapeyron equation which relates changes in pressure and temperature in the mixed-phase region:

$$dp/dT = \Delta S/\Delta v \qquad (3.1)$$

The consequences of this relation to shock wave propagation have been developed in some detail in Reference (7). One of the important results is a relation between dp/dT and the slope of the Hugoniot in the coexistence region (8):

$$(dp/dT)^2 + A(dp/dT) + B = 0 \qquad (3.2)$$

where

$$A = 2\alpha_1/\beta_M - \beta_1)$$

$$B = -C_{p1}/Tv_1(\beta_M - \beta_1)$$

$$\beta_M = -(1/v)(dv/dp)_M = \text{Hugoniot}$$
compressibility in mixed phase

β_1 = isothermal compressibility

α_1 = volume expansion coefficient at
constant pressure

C_{p1} = specific heat at constant pressure

Subscript "1" denotes evaluation in phase one
at the phase boundary.

Measurements made on bismuth, iron and quartz allow dp/dT to be estimated from Eq. (3.2). Results are entered in Table V where static values are also given for comparison. Values of α_1 and C_{p1} at atmospheric pressure and room temperature were used in the estimates, and β_1 was estimated from shock measurements.

TABLE V

The Coefficient dp/dT from Static and
Shock Wave Experiments

Type of Experiment	Sample		
	Bismuth	Iron	Quartz
Static measurements	-.05 (9)*	-.065 (10)*	.018 (11)*
Shock wave measurements (calculated from Eq. (3.2))	-.067 ± .045 (7)*	-.29 ± .115 (7)*	.225 (7)*

*Refer to sources in "Literature Cited."

From the table it is apparent that shock wave data for iron and quartz do not agree with those of static experiments. The errors in shock measurements shown in the table are estimated upper bounds based on errors in measurements of β_M. Therefore