experiments. Such experiments show that the iron transformation begins near 130 kbar and goes to completion for stresses greater than 150 kbar.[32,33,34,35] This behavior disagrees with equilibrium thermodynamics, which requires complete transformation to occur at constant stress when temperature is held constant. This requirement appears never to be realized experimentally. A very thorough investigation of the Bismuth I-Bismuth II transformation by Zeto and Vanfleet[6] shows that the onset of transformation in their apparatus always occurs at greater pressure than does the reverse transformation. They and others take equilibrium pressure of the transformation equal to the mean of direct and reverse transformation pressures.

An anomaly exists in static isothermal compression data which has not been carefully discussed in the literature: In some experiments iron appears to transform completely at the transformation pressure, while in other experiments with the same equipment the lower phase persists to higher pressures. No attempt is made to explain this anomaly because it involves analysis of static compression equipment and techniques which is beyond the ability of the author and the intended scope of this dissertation.

1.3. Outline of This Work

The basic problem studied in this work is the body-centered-cubic (alpha) to hexagonal-close-packed (epsilon) transformation in iron under shock compression. Iron samples were all initially at room temperature prior to shock loading.

Measurements were made of the evolution of shock waves with different sample thicknesses for approximately constant final driving stress. Experimental data were interpreted with the aid of a mixed phase continuum model with constant relaxation time to obtain some information about kinetics of the process. Hugoniot measurements in the mixed phase region are shown to correlate well with a simple relation between difference of Gibbs energies and fraction of material transformed. Some factors relating to deviations from equilibrium in the mixed phase region are explored.

1.4. Summary

The reasons for choosing to study iron were: (1) there exists a wealth of thermodynamic data on iron, (2) effects of the time-dependent phase transformation on shock profiles have been theoretically calculated by Horie and Duvall[20] and later by Andrews,[27,29] and (3) the elastic precursor stress amplitude does not depend on final driving stress for sample thicknesses of 3 mm or greater.[36]

The experimental intent of this study was to measure the evolution of the plastic I shock in polycrystalline Armco iron when final driving stress was 201 kbar. Basic findings were: (1) stress behind the plastic I shock increases from 131 to 140 kbar when sample thickness decreases from 25 to 1 mm, (2) transformation stress measured in a 25.4-mm-thick sample is 131.4 ± 3.3 kbar, (3) little or no variation of plastic I wave amplitude for propagation distances between 0.9 and