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# ON THE COMPRESSIBILITY OF THE ALKALI METALS*

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**Abstract** – A detailed comparison of shock wave and static compression data for alkali metals reveals serious inconsistencies above 40 kbar. The reduction of shock wave results is reviewed, and the Bridgman high-pressure data on the alkali metals are described. It is shown that the most likely cause of this disagreement is inaccuracy in the static high-pressure data.

## INTRODUCTION

IT IS GENERALLY believed that the pressure-volume compression relationships for solids has been reliably determined by experiment below 100 kbar because of the reasonable agreement between high pressure compression data from both static and dynamic compression techniques. The conclusion was reached, for instance, on the basis of the consistency of X-ray compression data[1] when normalized to the shock compression of several different metals. Such comparisons, however, have been restricted mainly to solids of moderate to-small compressibilities. Because of the great importance of the highly compressible alkali metals in solid-state physics, attention should be called to the fact that static and shock compression data on these metals below 100 kbar are in obvious and serious disagreement.

This situation is illustrated in Figs. 1–4 wherein Bridgman's isothermal compression data of 1948[2] for Li, Na, K and Rb are compared with the locus of shock compression points (the 'Hugoniot' curve) obtained by Rice[3] and Bakanova *et al.*[4]. A similar data comparison for Cs is not included because of the complication of two first-order solid–solid phase transitions at low pressure[2]. The two sets of shock compression data are in agreement except in the case of Li. The higher compressibility of Li as shown by the Russian data is not understood, but for the present purposes it may be overlooked since it only increases the disagreement we are pointing out. In all cases the shock compression data and Bridgman's isothermal data are nearly coincident, with Bridgman reporting slightly lower compressibilities in all cases. Recently, additional static compression measurements have been made at several temperatures on sodium[5] and potassium[6] up to 20 kbar, as well as ultrasonic velocity measurements up to 10 kbar[7, 8]. However, it appears that the extrapolation of these data to the range of 50–100 kbar cannot be done with sufficient accuracy to be useful in our data comparison. Below 50 kbar the various sets of data are consistent within experimental error.

In the case of highly compressible solids

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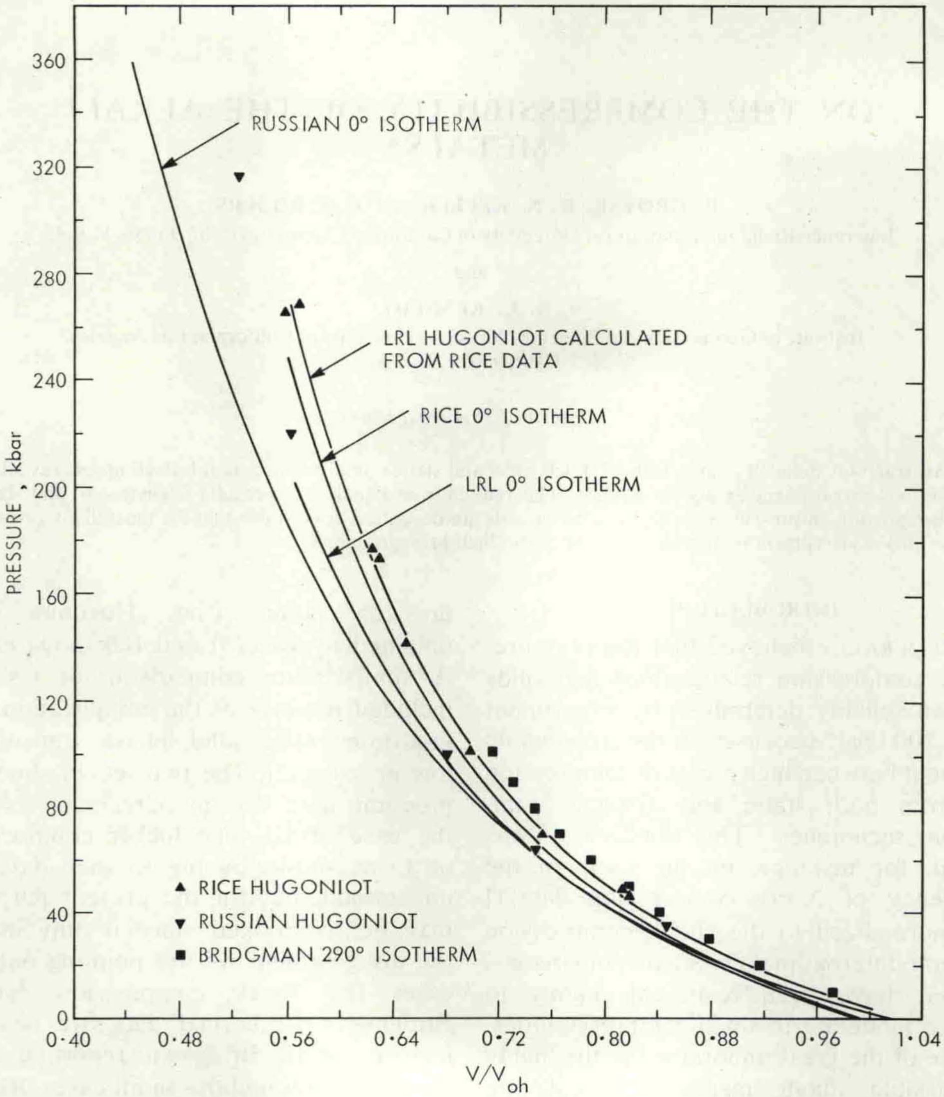


Fig. 1. Comparison of Bridgman isothermal compression data with shock data and calculated isotherms for lithium.

like the alkali metals, a large thermal correction must be made to the shock Hugoniot to obtain a 25°C isotherm for comparison with the Bridgman's data. The irreversible heating that occurs upon shock compression causes the temperature along the Hugoniot to increase with compression. Assuming that the compressed state of the metal behind the shock front is a state of thermodynamic equilibrium, the calculated shock temperatures are not a sensitive function of the assumed thermal equation of state of the metal. The increase in shock temperature with compression, as calculated from Rice's data, is seen in Tables 1–4 to be very rapid for these compressible metals.

The reduction of a Hugoniot to yield a 25°C isotherm, however, depends sensitively