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DISCUSSION

A. WEGENER SLEESWIJK, Amsterdam (The Netherlands): Referring to the remarks about the heat input due to the friction: the calculation of Prof. Bridgman refers only, I believe, to the *overall* heating of the material. On the other hand the researches of Prof. Bowden at Cambridge University have shown conclusively the *local* heating of the grains may easily take the material to temperatures near the melting point. In this connection it might be interesting to know what the estimated energy input due to friction was.

R. A. LAUDISE, Murray Hill, N.Y. (U.S.A.): (1) Have you considered the possibility that due to the manner in which your "displacive stress" is applied that local heating such as is known in ordinary grinding operations may be taking place?

(2) Have you studied the effect of the rate of rotation and the angle through which the rotation takes place on the kinetics of transformations?

Author's reply: In reply to the first question of Laudise, which is similar to that of Dr. Wegener Sleeswijk, it should be said that we have, of course, considered the question of "heating by friction" very seriously. The calculations we have carried out—quite analogous to those of Bridgman's—show that the whole sample cannot be heated by more than 5° C, and in all probability it may be as low as fractions of a degree. It is quite true, as the latter discussant has pointed out, that this does refer to a "bulk" heating. The reasons we have not given much further thought to this matter are:

(1) Even our calculations are extremely crude; to make calculations about "local" heating would require very far-reaching assumptions about the one as involved, the coefficients of friction etc.

(2) We believe that our data here provide the very best evidence that in fact the effect is *not* due to local heating. It should be noted that in every case we go from the high temperature (low pressure) phase to the low temperature (high pressure) phase. If there was a heating effect this would both favor the retention of the low pressure form as well as resulting in a diminished effect of shear with temperature.

If the "local heating" concept is applied to the question of the activation energy under shear, then we may be dealing only with a question of semantics. What we have described as the introduction of lattice strain—the mean relative displacement of the ions in the lattice from their *equilibrium* sites for that pressure and temperature—can be conceived of also as a quenching in of thermal vibrations corresponding to a much higher temperature. Local "heating" at a freshly broken surface must then also be said to be intense.

In reply to the second question by Laudise we do not have available as yet a wide enough range of rates of shear, but within our range (only 4:1) there is no marked change. We expect to try much greater rates shortly.

CYRUS KLINGSBERG, Washington D.C., (U.S.A.): If displacive shear is unlike isotactic pressure as a parameter except towards equilibrium conditions, then should we not expect a more frequent appearance of new metastable phases than are found?
Author's reply: This is a question of which we have been made aware, in the hope of finding new phases. It is true that we have not found any as yet but we have studied perhaps only 50 phases. Also it may be added that the disordered ZnS which can be produced by grinding either sphalerite or wurtzite is an example of such a phase, though a poor one.

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