Their analysis is based on the assumption that the initial shocked state lies on the hydrostat rather than above it by (2/3)Y as predicted by elastic-plastic theory. Other experiments by these investigators, involving free-surface velocity measurements at an impact pressure of 313 kbar, indicate a yield stress of 14 kbar when analyzed according to conventional elastic-plastic theory.[59] The two sets of experimental results are compatible; the factor of two discrepancy is the result of different assumptions about the shocked state.

Similar experiments have been conducted in magnesium by Fuller and Price.[60] Their results are also compatible with the assumption that yield stress increases under pressure, attaining values perhaps two to five times the zero pressure value (1 kb) at a shock stress of 80 kb.

A limited amount of work comparing shock and hydrostatic compression has also been performed on covalent and ionic solids. The first experiments were those on quartz, which appeared to show that the stress difference, (2/3)Y, that might be expected between the R-H curve and the hydrostat above the yield point does not obtain.[61,62] The conclusion was that the material loses rigidity at the yield point and that, therefore, the yield mechanism is fundamentally different in those materials than in metals. Comparison of the shock data with more recent hydrostatic data,[63] however, does indicate an appreciable difference, so that the elastic-plastic model, modified to include stress relaxation, may be at least phenomenologically reasonable.* (Fig. 15) Similar results have also been obtained for Al_2O_3 in polycrystalline form.

Whether these latter results imply that brittle crystals such as quartz and Al_2O_3 can deform extensively by dislocation motion under shock conditions is not clear. If so, the dislocation mobilities must be substantially

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*I am indebted to Dr. E. B. Royce for pointing this out. R. A. Graham points out, however, that the states above the elastic limit for different orientations of the quartz fall on the same curve. Moreover, there is a large reduction in electric polarization behind the second shock front. These observations are consistent with loss of rigidity above the elastic limit.

increased under shock. Recovered samples from experiments of this type are usually in the form of powder so that brittle fracture occurs somewhere in the shock and rarefaction process. Possibly fracture is the dominant yielding mechanism in the compression part of the wave, but intergranular friction maintains sufficient shear stress to give the stress differences observed. The shear stresses calculated for the elastic wave are very much higher than for metals and approach theoretical shear stresses for perfect crystals.[61,62]

It should be noted that other data still indicate a loss of rigidity above the yield point, notably in single crystal MgO[65] and Al_2O_3.[66]

Many materials, including metals and ionic and covalent crystals, exhibit stress relaxation. This is most easily observed in the decay of the elastic precursor wave with distance of travel from the impact surface, and in the structure of the wave between the elastic and plastic shock fronts. Stress relaxation, or strain-rate, effects are also important in the plastic shock front and, although the structure of this front can be resolved in many experiments at low stresses, only modest effort has thus far been made to correlate the shock structure with strain-rate models.

From the stress relaxation relations (Section III.D.) the plastic strain-rate at the elastic front can be determined from the rate of decay of the peak stress of the elastic wave. The relation is:

$$dP/dt = -F/2$$

where F is the plastic strain-rate multiplied by twice the shear modulus. This can be combined with the relation from dislocation theory:

$$\dot{\gamma} = (1/2)bNv$$

where $\dot{\gamma}$ is the plastic strain rate, b is the Burger's vector, N is the mobile dislocation density and v the velocity of dislocation motion.

Since the elastic front is very steep it is assumed that no time is available for multiplication of dislocations. Hence, $N = N_0$, the initial