dislocation density. If it is further assumed that, following Gilman, the dislocation velocities are given by,[40]

$$v = v^{\infty} \exp -D/\tau$$

where v^{∞} is the limiting dislocation velocity, D is a parameter called the drag stress, and τ is the shear stress, the equations above can be combined and integrated to give the peak elastic stress as a function of distance of travel and impact stress.[68] Comparison of the data then yields a set of compatible values for N_o and D for a given impact stress.

The most detailed study of elastic precursor decay has been performed on Armco iron by Taylor.[40] His results are shown in Fig. 16. Reasonable values of N_o and D do indeed give a good fit to these data, lending support to the theoretical model. Johnson, however, has recently pointed out that Taylor assumed that only one slip system of several possible systems was active in the (polycrystalline) iron.[67] If all systems are taken into account through an averaging process the necessary dislocation density is increased by a factor of about five. This density seems somewhat high compared to that obtained from independent measurements; consequently, the validity of the model is still somewhat tenuous. Kelly and Gillis point out that under the right conditions one might be able to discriminate between various dislocation models by experiments of this type.[68]

Precursor decay has also been studied in iron by Ivanov, et al,[69] in quartzite by Johnson,[39] and in aluminum by Barker, et al.[36]

Jones and Holland have studied the effect of grain size on the Hugoniot elastic limit in mild steel.[70] Although static tensile tests showed marked differences in the upper and lower yield point with varying grain size, no effect on the Hugoniot elastic limit was observed. They conclude that under the impact-loading conditions employed dislocations do not move far enough to encounter grain boundaries -- in contrast to the case of static yielding. The dynamic yield points, moreover, were two to three times those of the static experiments. They have also observed Bauschinger effects in pre-strained specimens.[71]

C. Porous Solids

There is considerable interest in shock propagation in porous solids, not only because equation of state data can be obtained over a wide range of densities and internal energies, as mentioned above, but also because porous solids possess excellent shock buffering characteristics. Hence, they can be used for the protection of structures from shock damage.

The collapse of pore space leads to large losses of internal energy as mechanical energy. In a steady state shock the internal energy is given by Eq. (3):

$$E - E_o = (P+P_o)(V_o-V)/2 \tag{3}$$

The compressed specific volume is not highly sensitive to the energy; consequently, to a first approximation we can neglect the energy dependence of the P-V curve and visualize the energy loss as indicated in Fig. 17.

In the solid material, with initial volume V_s, a steady shock to pressure P_1 carries the material along the Rayleigh line joining P_1 and V_s. The triangular area under the Rayleigh line represents the internal energy of the shocked state. The portion of this internal energy recoverable as mechanical energy is approximately the area under the R-H curve. Hence the mechanical energy loss is the sliver-shaped area between the Rayleigh line and the associated R-H curve. Clearly, this area increases substantially with V_o as the porosity is increased.

The mechanisms for energy loss cannot be precisely stated because the solid is three-dimensional on the scale of the pore size. However, the principal mechanism is probably initially the conversion of directed kinetic energy in the propagation direction to acoustic energy propagating in random directions; various dissipative mechanisms then convert this energy to heat.

Thouvenin has proposed a one-dimensional model (plate-gap model) for a porous solid which allows no mechanism for energy losses.[50] Consequently,