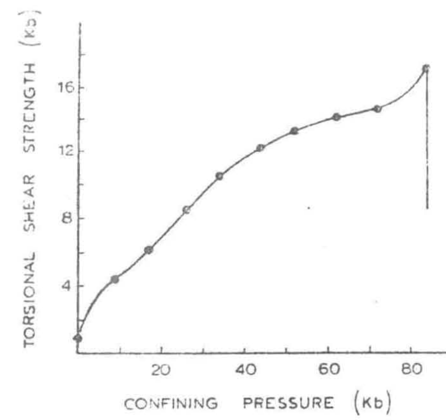

Fig. 3. The room temperature torsional shear strength of granodiorite at a series of static confining pressures (solid circles) while 3° twists were applied at a rate of 10^{-4} rad s^{-1}. One of the dual granodiorite samples underwent an explosivelike failure at about 85 kbar of pressure. As in other such occurrences, the shear strength dropped to one half of the maximum that was attained just prior to failure, a total loss of strength in the one sample that underwent catastrophic failure and total retention of the maximum strength in the second sample that did not fail thus being reflected.

val of pressure even though bulk consolidation appeared complete by about 15 kbar. *Bridgman* [1936] believed that the successive stress drops and acoustical emissions reflected the occurrences of brittle ruptures in regions that had become saturated with permissible slips. This explanation could not be verified because of the complexity of stressed microstructures. It was noted, however, that significant displacement was not present at rupture sites. This absence is interpreted as indicating that extensional-type ruptures persist to 40 kbar of pressure.

A further reduction in the rate of shear strength increase occurred at 35–40 kbar. The new rate remained relatively constant to about 75–80 kbar. Abrupt irregularities in the shear strength curve continued between 40 and 80 kbar but with increasing intensity of stress drop and acoustical emission. The rate of strength recovery after each abrupt drop was high. Examination of microstructures revealed that predominant residual strains consisted of intragranular multiple slips and also numerous short irregular intragranular disruptions. The latter had a networklike appearance. At high magnification, with polarizers crossed, the networks appeared as optically isotropic material without sharply defined boundaries. They may reflect a more intense mode of plastic strain than planar slips. Both lamellar and networklike disruptions are believed to represent shear-strain-induced fusion phenomena along intragranular regions of high defect concentration, according to the mechanism of *Orowan* [1960] for unstable creep.

Although the mechanism responsible for the abrupt minor stress drops, concomitant acoustical emissions, and rapid strength recoveries observed in torsional tests is not known, these phenomena are observed only after the onset of plastic deformations in the microstructure. It is possible therefore that they are due to sudden onsets of families of these intragranular deformations after critical absorption of strains. If this speculation is correct, the stress drops reflect a limited stress relief through limited and anisotropic strain-induced fusions within intragranular regions.

At 75–80 kbar the torsional shear strength experienced a sudden upturn that continued to about 85 kbar of pressure. A maximum strength was attained at about 85 kbar, whereupon samples underwent an explosivelike bulk failure (large acoustical shock, often accompanied by a blue flash at the sample site, and an instantaneous drop of the shear stress to zero on the sample undergoing failure). Except for magnitude, the pattern of the terminal shear strength rise and drop was similar to that observed for the irregularities described above for the pressure range 40–80 kbar.

Between 75 and 85 kbar the residual microstructures showed a significant increase in the concentration of small irregular optically isotropic regions, a spread of anomalous birefringence over intergranular space, and transgression of slip bands across grain boundaries (Figure 4, top). Those microstructures that experienced explosivelike failure showed extensive relatively broad parallel bands. Alternate bands were optically birefringent and isotropic. In spite of accumulated strain effects, original grain boundaries usually could still at least be partially discerned by means of interference colors, and the boundaries appeared to be mainly undisturbed (Figure 4, bottom).

An interpretation of the mechanical behavior near 85 kbar was given in terms of microstructural observations. The sharp rise in shear strength was attributed to a critical saturation of localized stress relief phenomena as represented by random intragranular slips and ruptures. Once a saturation of intragranular disruptions became widespread, further response to stress would be that of an isotropic bulk recapable of absorbing a bulk elastic strain. Since dispersed local slip mechanisms could no longer function to relieve stress, a disruption would propagate throughout the sample once it had initiated.

The extensive optically isotropic bands observed in microstructures that underwent catastrophic failure (Figure 4, bottom) appeared as glassy material. They are believed to represent lamellar sections of rock that experienced rapid shear-strain-induced fusion. This phenomenon is considered to be the cause of the catastrophic bulk failure that was repeatedly observed at about 85 kbar of confining pressure.

If this interpretation is valid, a correlation should exist between the quantity of elastic energy present at failure and the quantity of granodiorite fused. Figure 4 (bottom), which illustrates a selected area, shows the relative quantity of fused lamellas to be <0.5. The amount for the complete disk is more correctly given as <<0.5.

The stored elastic strain energy at failure is defined as the work energy of disruption. When the relationship $dW = VS\,de$ is used, where W is work energy, e is elastic strain, V is sample volume, and S is shear stress at failure ke, where k is the elastic constant at failure, and integration is performed,

$$W = S^2 V/2k$$

From Figure 2, when the terminal increment of sharply increasing shear stress is used, $\bar{e} \approx 0.05$, $k \approx 120$ kbar, and $S \approx 16.5$ kbar. If a density of 3.2 g cm^{-3} at 85 kbar of pressure is assumed, $V \approx 0.5$ cm^3. These data give a value of $\sim 5.7 \times 10^8$ ergs for the elastic work energy. Since only one disk of the dual-disk sample undergoes explosivelike failure (the other maintains full rigidity), the elastic energy released at failure is $\sim 2.9 \times 10^8$ ergs. It is assumed that about half this quantity will act to cause fusion on planes of disruption (the lamellas indicative of fusion), and the remaining half will be dissipated as acoustical and electromagnetic radiations (the explosionlike noise and blue flash). The energy consumed in fusion therefore is

$$E_f \approx 1.5 \times 10^8 (2.38 \times 10^{-8} \text{ g cal erg}^{-1}) \approx 3.5 \text{ cal}$$