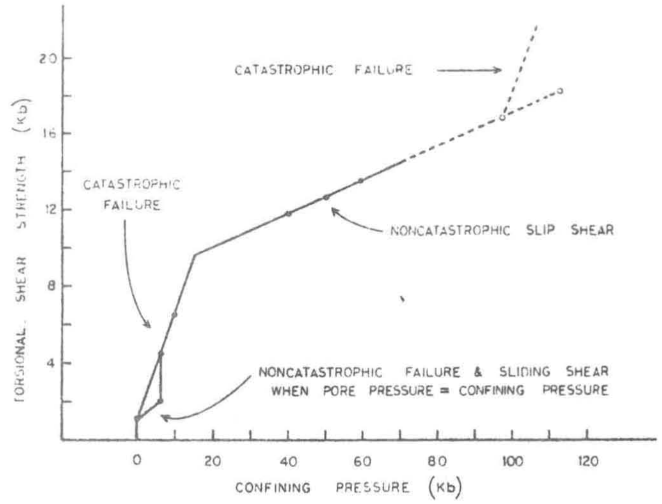

Fig. 1. The postulated failure diagram for normally brittle plutonic rock given by *Giardini* [1969].

showed transformation to a diminished rate of increase with increasing pressure. The new rate remained relatively constant to a pressure of 35–40 kbar. Between 15 and 40 kbar the shear strength underwent a succession of minor but abrupt drops and recoveries. Each drop was accompanied by a mild acoustical emission similar to that noted by *Bridgman* [1936] in earlier torsional tests.

Over the range 15–40 kbar the residual microstructures were observed first to display intragranular anomalous birefringences and then intragranular slips. The least rigid mineral (mica) reacted first, and the most rigid (quartz) reacted last. By 40 kbar all minerals had experienced slips. Intragranular transverse ruptures also continued over this interval continuously to about 85 kbar of pressure. This was accomplished with the torsional shear apparatus developed by *Abey and Stromberg* [1969]. Dual disk-shaped bulk samples, each 1.27 cm in diameter and 0.25 cm high, were used. The granodiorite was of the same origin as that used earlier by *Giardini et al.* [1968] in triaxial tests to about 6 kbar and by *Riecker and Rooney* [1966*a*] in torsional tests to about 60 kbar.

'Typical' torsional shear strengths measured for dry granodiorite over an initial 85 kbar of confining pressure are shown in Figure 2. In both cases confining pressure was continuously increased at a rate linear with the applied torque. The data given in Figure 2 (top) were obtained from 11° of twist smoothly applied at a rate of 10^{-4} rad s^{-1}. The data in Figure 2 (bottom) were obtained from 22° of twist applied at the same rate. Twist rates of 10^{-3} and 10^{-5} rad s^{-1} did not yield significantly different results.

A comparison of Figure 2 with Figure 1 reveals the similarity to the failure model constructed earlier from incomplete experimental data (Figure 1). Maximum torsional shear strengths also were obtained at various static confining pressures. Data from 3° twists applied at 10^{-4} rad s^{-1} under static confining pressures are summarized in Figure 3. These data also comply with the pattern of the failure model.

The initial rise in torsional shear strength over the first 15 kbar of pressure corresponds to the region of brittle shear failure established earlier in triaxial tests [*Giardini et al.*, 1968]. The rate of torsional strength increase is less than that obtained from triaxial tests, but this difference is attributed to experimental difficulties inherent in the torsional method used [*Giardini and Abey*, 1972].

A comparison of microstructures before and after the application of torsional stress and pressure to 15 kbar revealed that residual strain effects were mainly point-contact-induced intragranular ruptures and displacements eliminating interstitial free space [*Giardini and Abey*, 1973]. At about 15 kbar the reduction of free space was such that grains began to experience total crystalline confinement. Indications of nondisruptive deformations (intragranular slips) were first observed in mica at about 10 kbar of confining pressure.

At about 15 kbar the shear strength curve (Figure 2)

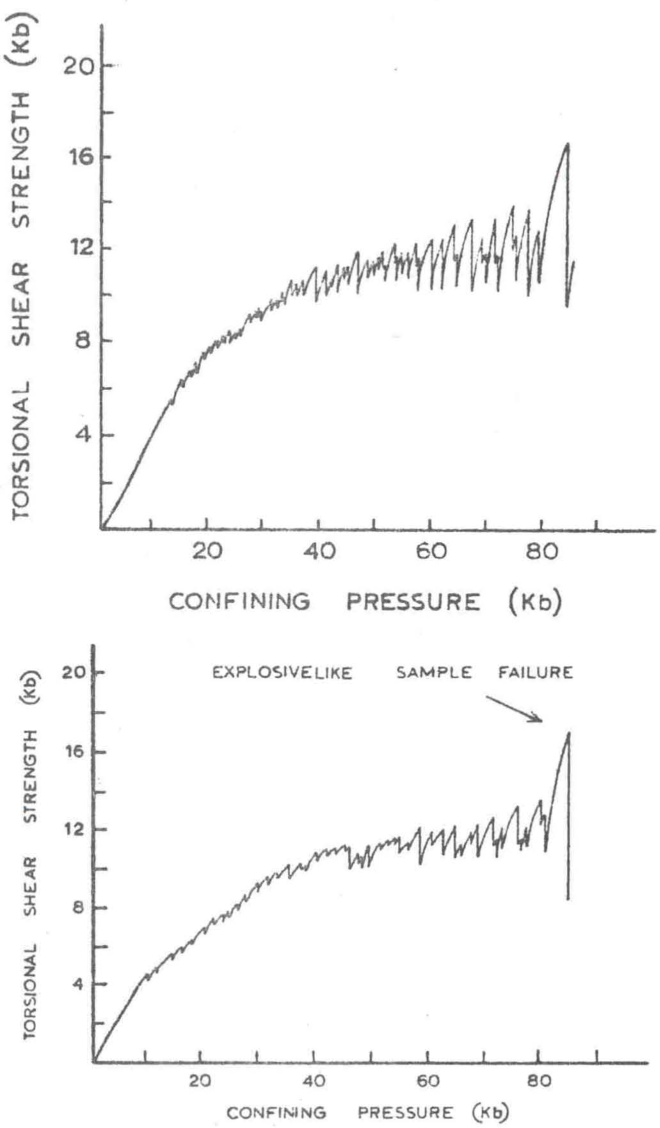

Fig. 2. (Top) The room temperature shear strength of granodiorite obtained with the Abey-Stromberg apparatus using dual disk-shaped samples 1.27 cm in diameter and 0.25 cm high. The samples were subjected to 11° of applied twist at a rate of 10^{-4} rad s^{-1} concurrent with a linearly increasing confining pressure to 85 kbar. The experiment was terminated short of an explosivelike failure of the rock. (Bottom) The room temperature torsional shear strength of granodiorite to about 85 kbar of linearly increasing pressure with 22° of twist concurrently applied at a rate of 10^{-4} rad s^{-1}. Here one of the dual-disk-shaped samples underwent explosivelike failure at about 85 kbar of confining pressure. Shear strength values along the irregular part of this curve and other shear strength curves given in this paper refer to maximums along the curves.