Fig. 4. (Top) A view of a typical granodiorite microstructure that did not fail explosively after about 85 kbar of pressure with torsional shear. The presence of multiple slip bands extending across grain boundaries and a dense concentration of small irregular optically isotropic regions (irregular small black areas) are illustrated. The microphotograph was taken at a microscope magnification of ×40 with polarizers crossed. (Bottom) A view of a typical granodiorite microstructure of a part of a sample that failed in an explosivelike manner after about 85 kbar of pressure with torsional shear. The material is a segment of the sample that remained in its pressure chamber. The black parallel bands that extend across multiple grain boundaries are optically isotropic, whereas the alternate white bands are birefringent. The isotropic bands appear to be glass phase lamellas created by shear-strain-induced fusion of the rock. The microphotograph was taken under conditions identical to those of the top microphotograph.

The heat of fusion of granodiorite is not known. However, *Kesler and Heath* [1968] have used $H_0 \approx 65$ cal g^{-1} for dry granitic rock at 1 bar. By using this value and assuming that ΔV for solid and fused states is essentially independent of pressure, T_0 (fusion) at 1 bar is approximately 1400°K, and $\Delta T/\Delta P \approx 10°$ kbar^{-1}, the heat of fusion at 85 kbar for one disk (0.8 g) is estimated to be

$$H_{85} \approx H_0 (T_{85}/T_0) \, 0.8 \approx 65 \, (1.6) \, 0.8 \approx 83 \text{ cal}$$

The ratio 3.5/83 gives the approximate fractional volume of granodiorite that can undergo an adiabatic shear strain fusion upon failure. The two approximations, ≪0.5 and 0.04, are qualitatively consistent.

The above argument also applies to those lesser abrupt stress drops that precede catastrophic bulk failure and that have been interpreted as reflecting more restricted volumes of sample fusion.

Granodiorite with a simulated pore fluid (AgCl). It was not possible for *Giardini and Abey* [1973] to contain a true pore liquid within the sample with the Abey-Stromberg apparatus. It was possible, however, to simulate a pore fluid by chemically precipitating a thin film of AgCl within the pore network of the rock. It is generally accepted that AgCl maintains an exceptionally weak shear strength over the pressure range of the torsional tests, and it is widely used in high-pressure work to achieve near-hydrostatic environments. A room temperature phase transformation does occur in AgCl at about 75 kbar [*Bridgman*, 1945 (corrected)], but it does not appear to cause a significant change in mechanical properties.

The room temperature shear strength obtained by Giardini and Abey for granodiorite with interstitial AgCl is shown in Figure 5. The initial steep rise in strength found for dry rock was not observed until the pressure was raised to 3–5 kbar. The initial region of low shear strength is similar to that found earlier in triaxial tests where a true pore fluid pressure did exist [*Giardini et al.*, 1968]. (In the published triaxial test work the presence of a pore pressure was suspected but not experimentally proven. Later unpublished triaxial tests on granodiorite definitely confirmed that the confining pressure liquid (Dow silicone oil) had penetrated the sample jacket at its ends in those cases where noncatastrophic failures were encountered. When Dow 'silastic' adhesive was used on the jacket ends, fluid penetration to the sample did not occur, and catastrophic shear failures invariably occurred.) The transition to a steeply increasing strength at about 5 kbar is believed to reflect disruption of the AgCl film network in the rock.

A limit for sliding shear in homogeneous rock having an internal fluid pressure can be established from data given by *Giardini et al.* [1968, Figure 7]. It can be stated as

$$P = P_p + P_n$$

where P is the external confining pressure, P_p is the component of internal fluid pressure opposed to P_n, and P_n is the internal component of rock pressure acting normal to the rupture plane.

When $P_p = P$, $P_n = 0$, and sliding motion along a rupture plane is limited only by the viscosity of the fluid. When $P_p = 0$, the pressurized fluid network no longer exists, and $P_n = P$. Sliding is thereupon limited by the coefficient of friction for the dry rock. Since the coefficient becomes of the order of unity beyond a small value of P, the dry sliding strength ap-
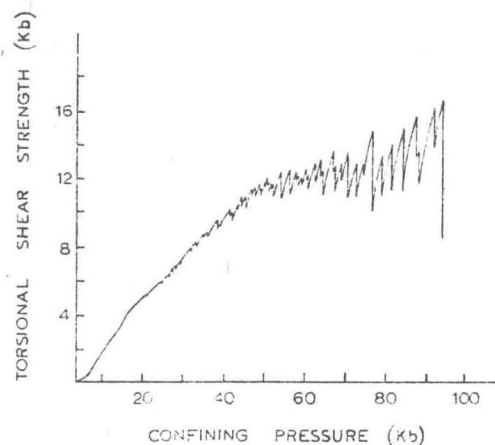

Fig. 5. The room temperature torsional shear strength of dual granodiorite samples that contained a chemically precipitated interstitial film of AgCl. The rather large stress drop at about 75 kbar is believed to represent a phase transformation of the AgCl. One of the dual samples underwent abrupt failure at about 95 kbar of pressure.