suggesting the occurrence of slip on prism planes. In single-crystal experiments, these *c*-axis lamellae have been found often in the $\perp r$ and $\perp z$ crystals and are rare in 0^+ crystals. This suggests that interference between the two basal slip systems may increase the shear stress sufficiently to allow prismatic slip to develop. The formation of *c*-axis lamellae with arrays of prismatic dislocations may be important in trapping basal dislocations and producing kink bands in the $\perp r$ and $\perp z$ crystals.

The average asymmetry of the boundaries noted above ($\theta_1 = 88°$, $\theta_2 = 102°$) corresponds to a difference in length parallel to *c* of 2.2 per cent between the host crystal and band. If this were due to elastic strain there would be equal compressive and tensile stresses in the kink band and host, respectively, of approximately 11 kb. roughly parallel to the kink-band boundary.

An alternative possibility is that secondary slip would occur with dislocations becoming locked at the kink-band boundary to accommodate this difference in host and kink band. The most likely system of secondary slip in our crystals is slip parallel to the *c*-axis, since the resolved shear stress is high parallel to *c* on some prismatic planes in the crystals which develop *c*-axis kink bands, and there is evidence of prismatic slip in the absence of kink bands as noted below. The way in which prismatic slip by edge dislocations with Burgers vector parallel to *c* could account for the asymmetry is illustrated in figure 6, *d*. The average asymmetry observed would require 4×10^5 such dislocations per centimeter of the kink-band boundary, assuming a Burgers vector equal to 5.39 Å—the lattice spacing in quartz parallel to *c*.

In figure 6, *d* just enough prismatic dislocations have been added to reduce the crystal strain to zero away from the immediate vicinity of the kink-band boundary. Hence the stress field of this prismatic array will be negligible at distances greater than the spacing between the prismatic dislocations (250 Å). Such a boundary would thus produce no optically observable effect, as is the case in most of the boundaries.

Some kink-band boundaries exhibit changes in indices and birefringence similar to lamellae. These are most evident, however, in light vibrating parallel to ω, rather than ϵ, as in the case of basal lamellae. The indices are higher on the deformed-band side. This is what would be expected in an undeformed crystal if an array of prismatic dislocations of sign opposite to that shown in figure 6, *d* were inserted. It is also the same as if there were a deficiency of prismatic dislocations in figure 6, *d*.

Let us explore this effect quantitatively. Using the elastic constants and Burgers vector appropriate to our commonest case (with the dislocation lines parallel to x_1), and proceeding as in the above case for the basal array, the calculated changes in index are

$$n_{11} = .203 \frac{b}{h}$$

$$n_{22} = .220 \frac{b}{h}$$

$$n_{33} = .051 \frac{b}{h}.$$

The change in ω is much greater than the change in ϵ, consistent with the observation that the kink-band boundary lamellae are much more evident in light vibrating parallel to ω than parallel to ϵ.

If there were no prismatic dislocations at a kink-band boundary of average asymmetry, the optical effect would be equivalent to that produced by an array of 4×10^5 prismatic dislocations per centimeter. In this case, $b/h = .022$ and the changes in index and birefringence would be

$$\Delta n_{11} = .0044 \quad \Delta n_{33} - \Delta n_{11} = -.0033$$

$$\Delta n_{22} = .0047 \quad \Delta n_{33} - \Delta n_{22} = -.0036\,.$$

$$\Delta n_{33} = .0011$$

Compression increases the indices but *decreases* the birefringence. The corresponding non-zero stress components are $\sigma_{11} = 1.5$ kb., $\sigma_{33} = 11$ kb., and $\sigma_{13} = 0.3$ kb. In the boundaries that look like lamellae, the indices are higher and the birefringence lower on the deformed side of the kink-band boundary, just as the dislocation theory predicts for a deficiency of prismatic dislocations of the sign required to compensate for the asymmetry.

The observed changes in birefringence, however, are less than .001. Hence we may conclude in these instances either that more than two-thirds of the prismatic dislocations required to compensate the elastic strain have actually developed, or that the stress is relieved by other means, such as fracture.

If the average boundaries were compensated by prismatic dislocations as in figure 6, *d*, these would be stable on release of stress—like grain boundaries. It is observed, however, that the less-deformed regions between kink bands are almost universally fractured at high angles to the kink-band boundary (pl. 3). This also shows that insufficient prismatic dislocations have developed to balance the tension normal to the basal plane in the host crystal.

The elastic stresses required in the absence of prismatic dislocations are shown above to be about 10 kb. Stresses of this magnitude are to be expected under the conditions of the experiments, but far exceed the measured values of tensile strength of quartz at room temperature and pressure, and would be expected to result in fracture at high angles to the kink-band boundary when pressure is released.

From all of the above observations, it is concluded that: (1) The kink bands developed by basal slip with basal dislocations becoming locked in the kink-band boundaries. (2) Asymmetry about the band boundaries develops because the boundary dislocations are locked in the crystal and cannot migrate to the symmetrical position. (3) The elastic strains caused by the asymmetry are not, in general, relieved by the formation of prismatic dislocations in the kink-band boundary. (4) These elastic strains persist at high pressure but are relieved by fracture when the pressure is removed.

EVIDENCE OF OTHER SLIP SYSTEMS

In crystals deformed so that the shear stress on the basal plane is high, the shear stress on some of the prism planes is also high. In several such single crystals deformation lamellae parallel to the *c*-axis and deformation bands subparallel to the base are found together with the more common basal lamellae and kink bands parallel to the *c*-axis. The basal bands and *c*-axis lamellae are commonly localized within broader *c*-axis bands. By analogy with the arguments given above for basal slip, the *c*-axis lamellae and basal bands suggest that slip occurs on prism planes, probably in the direction parallel to the *c*-axis. We do not yet have any observations of prismatic slip bands on polished crystals to confirm this mechanism. It should be noted, however, that the *c*-axis lamellae are much more evident when viewed in light vibrating parallel to ω than parallel to ϵ, consistent with the calculations in the preceding section for arrays of prismatic edge dislocations with Burgers vector parallel to *c*.

In crystals compressed parallel or normal to the *c*-axis, the shear stress on the basal plane is zero. In these crystals no lamellae or deformation bands parallel to the base or the *c*-axis are found. But lamellae and conjugate kink bands develop at inclinations of approximately 45° to the *c*-axis. Study of

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PLATE 3

A, Kink band (E.-W. boundary) in crystal C-267 (phase-contrast illumination). Deformation lamellae are much more profuse and closely spaced in more highly deformed band (below boundary). Note abundant fractures (appear white in phase contrast) in less deformed band (above boundary).

B, Photomicrographs (bright-field illumination) of a set of several parallel NE.-trending kink bands in crystal C-263. Bands containing abundant fractures at high angles to their boundaries are relatively less deformed. Lamellae are faintly visible in the clear, more highly deformed bands. Scale lines beneath photos represent 0.1 mm.