

mechanism for the formation of barriers to block active sources. The observed variation in σ_{III} at 1 atm in the alkali halides appears compatible with Fontaine's model, i.e., for roughly equal dislocation extensions on the primary slip plane ($\sim 5b$) the value of σ_{III} in the alkali halides should reflect a change in elastic constants; indeed σ_{III} for NaCl, KCl, and KI varies approximately in proportion to K_s (see Table I).

Direct experimental evidence to support the suggestion that cross slip controls stage III in the alkali halides is due to Matucha and Haasen²⁵; they found that surface cross slip traces on NaCl are observed only after deformation enters the third stage. These traces differ from those in metals, however, in that cross slip occurs consecutively on two different planes; from the primary $\{110\}$ plane, it proceeds to $\{111\}$, then to $\{100\}$ before returning to $\{110\}$. Matucha and Haasen suggest that cross slip first occurs on $\{111\}$ because dissociation is energetically favorable on this plane. The driving force for transfer of cross slip to $\{100\}$ cannot be increased dissociation, but rather must occur because slip over large distance on $\{111\}$ would lead to charged surface steps.

The proposed dissociation on $\{1\bar{1}0\}$ is²³

$$a/2[110] \rightarrow a/4[110] + a/4[1\bar{1}0].$$

The stacking fault brings unlike ions into juxtaposition across the fault plane, and thus, it is favored by a strong Coulombic energy contribution. It is opposed by an exchange contribution which is relaxed by a strong local dilation of the lattice perpendicular to the fault plane ($\delta d_{110}/d_{110} \approx 0.3$).²³ Consequently application of high pressure should result in an increase in stacking-fault energy, as proposed by Fontaine and Haasen.²⁴ The reduction in σ_{III} under pressure occurs because cross slip of screw dislocations depends on recombination of the partial dislocations. When γ is increased at high pressure the stacking-fault ribbon is narrowed and less stress is required to bring about recombination and, hence, cross slip. The stage III structure should thus begin to develop at lower stress (σ_{III}) at 4.3 kbar. The stacking-fault partials will also repel one another more strongly at pressure due to an increase in elastic constants. If this effect is significant it could forestall a decrease in σ_{III} and this perhaps explains the results for

KI. As $\delta K/K_{e,s}$ are about the same for NaCl and KCl, the reason for the different values of $\delta\sigma_{III}/\sigma_{III}$ for these materials is unclear. Possibly the stacking-fault dilation differs significantly in the alkali halides (greater in NaCl than in KCl or KI); presumably $\delta\sigma_{III}/\sigma_{III}$ would be more negative for greater dilation.

As noted in the results section, the work softening which occurs at high pressure in NaCl and KCl after prestrain at 1 atm is evidence of plastic instability. In light of the mechanism discussed here for stage III, it presumably occurs because, due to the increase in γ , some dislocation configurations stable at 1 atm are unstable at higher pressures. When deformation is re-initiated under pressure, cross slip occurs in a catastrophic fashion and a yield point develops. Experiments show that the rapid cross slip must be driven by external stress: If deformation in stage III at 1 atm is interrupted, the pressure increased to 4.3 kbar and then returned to 1 atm without loading at 4.3 kbar, there is no transient or permanent change of flow stress or work-hardening rate at 1 atm. Thus there is no motion of dislocations due to application of pressure alone.

A change in σ_{III} due to applied pressure means that cross slip must begin from a different stage II structure, or that the structure developed by cross slip must be in some way different, i.e., $d\sigma_{III}/dP$ is not a measure of the change of flow stress at constant structure. The flow stress increment $(\delta\sigma/\sigma)_s$, as determined in an interrupted test, is a measure of the latter quantity and at large strains one can expect a contribution to $(\delta\sigma/\sigma)_s$ from the change in elastic constants with pressure. For NaCl, KCl, and KI, however, $(\delta\sigma/\sigma)_s$ in stage III appears significantly less than $\delta K/K_{e,s}$; in fact, $\delta\sigma/\sigma_s$ for KCl may be slightly negative (Table II). Thus, besides causing the negative pressure dependence of the dislocation structure, i.e., negative $\delta\sigma_{III}/\sigma_{III}$, the cross-slip mechanism also makes a negative contribution to $(\delta\sigma/\sigma)_s$. A negative $d\sigma_s/dP$ implies a negative activation volume for the motion of dislocations in stage III.

ACKNOWLEDGMENTS

We would like to thank Mr. Murray Ruggiero for assistance with the experiments and Dr. P. Haasen for sending us information prior to publication. These studies have been supported by the U. S. Army Research Office (Durham).

²⁵ K. H. Matucha and P. Haasen, Nachr. Akad. Wiss. Goettingen, II. Math. Physik. Kl. 17, 219 (1967).