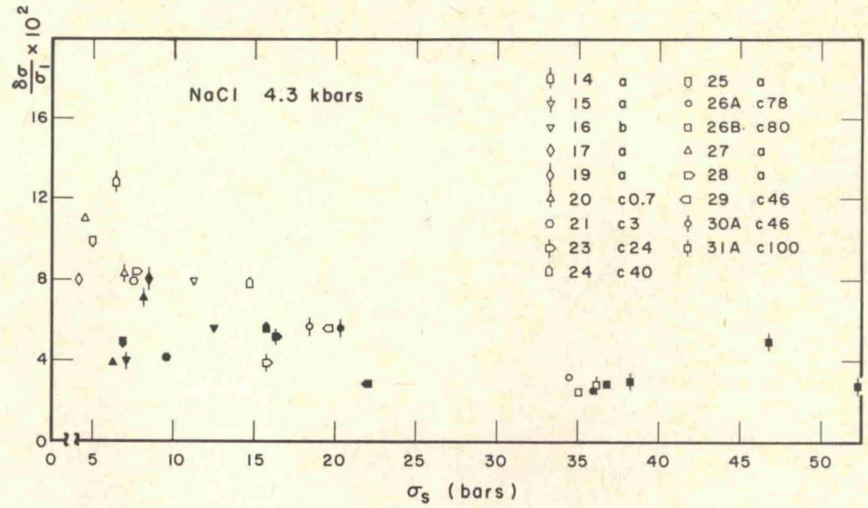

FIG. 15. The 4.3-kbar $\delta\sigma/\sigma$ data for NaCl. In the legend: a = as received, b = as received 1959 (also irradiated 1 h), cx = γ-ray irradiated x hours.

vs σ_s is given for KI, KBr, and CsBr. For KI, $\delta\sigma/\sigma$ varies from a high of 0.33 to a low of $\sim$0.12. The values for KBr range from 0.17 to 0.08. For CsBr $\delta\sigma/\sigma$ shows a maximum of $\sim$0.26 and a minimum of $\sim$0.15. Due to the serrated yielding phenomenon it is impossible to determine $\delta\sigma/\sigma$ on pressure release for the irradiated sample. In each case $\delta\sigma/\sigma$ decreases with σ_s, although the range of stress covered is not large.

DISCUSSION

Table II indicates that as one considers the alkali halides in the order of increasing interionic distance, the compression at 4.3 kbar $-\Delta V/V_0$, increases from LiF to RbI and then drops somewhat for CsBr, which has a different structure. As the value of $\delta\sigma/\sigma$, the fractional change in flow stress with pressure, varies in about the same way, to a first approximation there is a qualitative correlation with compressibility. Such a simple correlation offers an inadequate rationalization of the data, however, as the variation of $\delta\sigma/\sigma$ with yield stress indicates. In order to understand the variety of the results, it is necessary to consider in more detail the processes which limit dislocation mobility in a crystal.

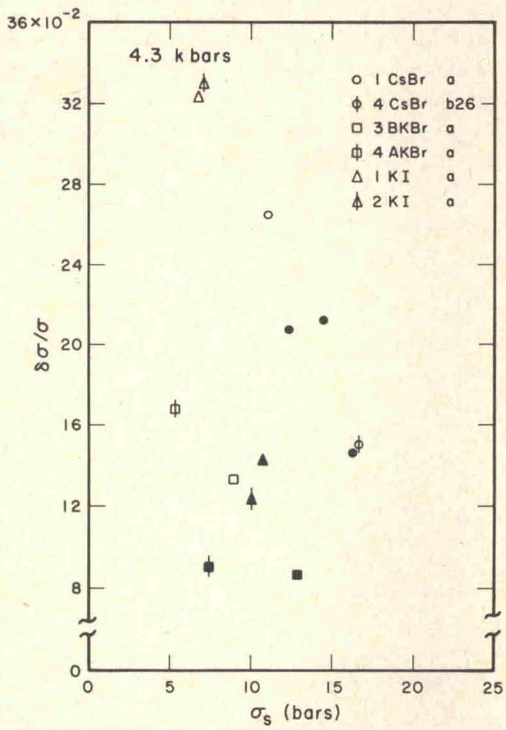

FIG. 16. The 4.3-kbar $\delta\sigma/\sigma$ data for CsBr, KBr, and KI. In the legend: a = as received, bx = γ-ray irradiated x hours.

The flow stress of a crystal is the sum of contributions from the Peierls force, σ_P, the elastic interaction of dislocations with impurity atoms or point defects (isolated or aggregated), σ_E, the creation of point defects or dragging of pinning points by moving dislocations, $\sigma_{\mathrm{P.D.}}$, and dislocation–dislocation elastic interactions, $\sigma_{\mathrm{D-D}}$. Due to the sensitivity of flow stress to impurity concentration, it is thought that σ_P in the alkali halides is relatively small and that, in the unworked crystal, σ_E is the dominant term. Fleischer[12] has analyzed the elastic interaction of randomly dispersed hardening centers with dislocations in cubic materials, distinguishing between "gradual" and "rapid" hardening. Multivalent impurities in the alkali halides produce rapid hardening due to formation of defects of tetragonal symmetry; the increase of σ with concentration, $d\sigma/dc$, is G to $10G$, where G is the shear modulus. Fleischer uses isotropic elasticity theory to derive $d\sigma/dc$ in terms of material properties and obtains quantitative results for the rapid increase of flow stress in LiF with irradiation; the tetragonal hardening defect is thought to be an interstitial anion or interstitial cluster. Sibley and Sonder[13] find that the same type of model applies for irradiated KCl.

In Fleischer's analysis, $d\sigma/dc$ is proportional to $G\Delta\epsilon$, where $\Delta\epsilon$ is the tetragonality of the hardening

[12] R. L. Fleischer, Acta Met. **10**, 835 (1962).

[13] W. A. Sibley and E. Sonder, J. Appl. Phys. **34**, 2366 (1963).

TABLE II. Experimental $\delta\sigma/\sigma$ data and calculated variables.

	$\delta\sigma/\sigma \times 10^2$	$\delta K_s/K_s \times 10^2$	$\delta K_e/K_e \times 10^2$	$-\Delta V/V_0 \times 10^2$	$V^* A^3$	$V_a A^3$
LiF	0.4 ± 2	2.81	3.15	0.65	~ 0	15.2
NaCl	13 ± 3				21	39.0
	3 ± 2	6.33	7.21	1.84	5	
KCl	25 ± 4				38	44.7
	8 ± 2	5.83	7.21	2.47	13	
KBr	17 ± 2				28	54.6
	~ 9	7.53	9.24	3.03		
KI	32 ± 3				49	71.6
	~ 13	10.3	13.0	3.90		
RbI (3.2 kbar)	30 ± 3				63	75.3
	~ 19	6.5 est.	9.4 est.	3.09		
CsBr	26 ± 2				40	49.4
	15 ± 2	20.8	13.3	2.97	24	

defect. In a material where σ_E determines the flow stress, $\delta\sigma/\sigma$ should equal the fractional change of G with pressure, $\delta G/G$, if the degree of tetragonality is unaffected by pressure; $\delta\sigma/\sigma$ should also equal $\delta G/G$ for a heavily work-hardened crystal where σ_{D-D} dominates. For anisotropic single crystals, G should be replaced with the appropriate modulus, K, for the stress field of a dislocation in an anisotropic material. These moduli have been given by Foreman[14] and are listed with their logarithmic pressure derivatives in Table III for edge and screw dislocations in the NaCl and CsCl structures. The pressure derivatives of the elastic stiffnesses are taken from the compilation by Barsch and Chang.[15] In computing $d\ln K_s/dP$ and $d\ln K_e/dP$, the isothermal elastic moduli and isothermal–isothermal pressure derivatives were used. The values of dc_{ij}/dP given by Barsch and Chang represent the initial slope of the change of modulus with pressure. The assumption is made that dc_{ij}/dP changes linearly with pressure. This is not correct, but most investigations of the pressure dependence of the elastic moduli terminate just when nonlinearity begins. The computed values of $\delta K_s/K_s$ and $\delta K_e/K_e$ for $\delta P = 4.3$ kbar (3.2 kbar for RbI) are given in Table II. It is necessary to estimate values for RbI as the required dc_{ij}/dP data are not available. This was accomplished by computing $\delta K_s/K_s$ and $\delta K_e/K_e$ for RbBr at 3.2 kbar and increasing the results in the ratio of the corresponding values for KBr and KI. Table II lists the highest and lowest values of $\delta\sigma/\sigma$ observed for comparison with $\delta K/K$. Figure 17 shows a comparison of $\delta\sigma/\sigma$, $\delta K_e/K_e$ and $\delta K_s/K_s$ for LiF, NaCl, KCl, and

TABLE III. Elastic constants K and their logarithmic derivatives.

NaCl structure

$$K_s = \{[(c_{11}-c_{12})/2]c_{44}\}^{1/2}$$

$$d\ln K_s/dP = \tfrac{1}{2}\{(c_{11}-c_{12})^{-1}d(c_{11}-c_{12})/dP + c_{44}^{-1}dc_{44}/dP\}$$

$$K_e = (c_{11}+c_{12})\{c_{44}(c_{11}-c_{12})/[c_{11}(c_{11}+c_{12}+2c_{44})]\}^{1/2}$$

$$d\ln K_e/dP = K_s^{-1}dK_s/dP - \tfrac{1}{2}\{c_{11}^{-1}dc_{11}/dP + (c_{11}+c_{12}+2c_{44})^{-1} d(c_{11}+c_{12}+2c_{44})/dP\} + (c_{11}+c_{12})^{-1}d(c_{11}+c_{12})/dP.$$

CsCl structure

$$K_s = c_{44}$$

$$d\ln K_s/dP = c_{44}^{-1}dc_{44}/dP$$

$$K_e = (\bar{c}_{12}+c_{12})\{2c_{44}(\bar{c}_{12}-c_{12})/[(c_{11}+c_{12}+2c_{44}) \times (\bar{c}_{12}+c_{12}+2c_{44})]\}^{1/2}$$

$$d\ln K_e/dP = (\bar{c}_{12}+c_{12})^{-1} \times d(\bar{c}_{12}+c_{12})/dP + \tfrac{1}{2}\{c_{44}^{-1}dc_{44}/dP + (\bar{c}_{12}-c_{12})^{-1} \times d(\bar{c}_{12}-c_{12})/dP - (c_{11}+c_{12}+2c_{44})^{-1} \times d(c_{11}+c_{12}+2c_{44})/dP - (\bar{c}_{12}+c_{12}+2c_{44})^{-1} \times d(\bar{c}_{12}+c_{12}+2c_{44})/dP\},$$

where $\bar{c}_{12} = \{\tfrac{1}{2}c_{11}(c_{11}+c_{12}+2c_{44})\}^{1/2}$.

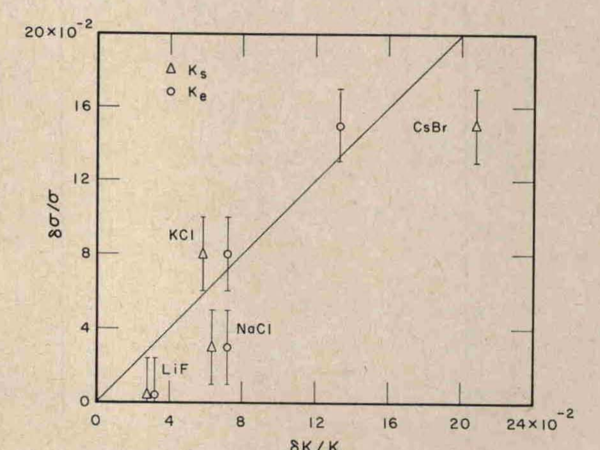

FIG. 17. A comparison of the fractional change of elastic modulus with pressure of 4.3 kbar for edge and screw dislocations with the fractional change of flow stress in hard crystals of LiF, NaCl, KCl, and CsBr.

[14] A. J. E. Foreman, Acta Met. **3**, 322 (1955).

[15] G. R. Barsch and Z. P. Chang, Phys. Status Solidi **19**, 139 (1967).