Finally, the rapid rise in resistivity above 15 kbar is apparently not associated with any pressure induced structural transformation. No new phase could be detected from high pressure X-ray diffraction measurements carried out at the National Aeronautical Laboratory, Bangalore, using a tungsten carbide anvil cell and a two film cassette [12].

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Stress relaxation in KCl single crystals

The Li–Gupta [1, 2] method of analysing stress relaxation data has had considerable success with bcc metals and many ionic crystals. The dislocation velocity–stress exponent, m^*, given in the empirical formula

$$\dot{\epsilon} = B\sigma_f^{m^*} \quad (1)$$

has been determined quite easily by this method. (In Equation 1, $\dot{\epsilon}$ is the strain rate, σ_f is the effective stress and B is a constant.) However, it is now clear that there are many materials with which Li–Gupta analysis breaks down [3]. KCl single crystal is one such material. Previously, we measured the stress relaxation of KCl single crystals and obtained the m^* values by this method [4], but the results obtained gave $m^* = \pm\infty$ at room temperature and negative values at temperatures higher than 150° C. (For instance, $m^* = -2.72$ at 450° C.) These are physically insignificant values. A similar result has been obtained by Ohring *et al.* [5] who measured the relaxation of decay current in deformed KCl single crystal.

On the other hand, the analytical method developed by Hart [6] has had remarkable success in analysing the stress relaxation of many metals and alkali halides. For instance, Lerner *et al.* [7] have analysed the stress relaxation of KI, LiF, NaCl and NaF single crystals according to Hart's theory. However, to the authors' knowledge, results for KCl have not been reported using this method. The purpose of this letter is to carry out, and report on the results, of the stress relaxation analysis of KCl single crystal by Hart's theory and to consider the reason why Li–Gupta analysis failed with this material.

First, the phenomenological model proposed by

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Hart [6] will be reviewed. It consists of two branches in parallel. One of the branches includes an anelastic spring (a) in series with a plastic element ($\dot{\alpha}$) which governs plastic deformation at high homologous temperatures and/or low strain rate.

The relation effective for this branch is

$$\ln(\sigma^*/\sigma_a) = (\dot{\epsilon}^*/\dot{\alpha})^{\lambda} \tag{2}$$

where σ^* is the hardness parameter of the specimen, σ_a is the stress at anelastic spring, $\dot{\alpha}$ is the plastic strain rate, $\dot{\epsilon}^*$ is the rate constant for the $\dot{\alpha}$-element. This is expressed by

$$\dot{\epsilon}^* = (\sigma^*/G)^m f \exp(-E/kT) \tag{3}$$

where G is the shear modulus, m, f and λ (in Equation 2) are constants, E is Young's modulus, T is temperature and k is Boltzman's constant.

The other branch contains a non-elastic friction element and is important at low homologous temperatures and/or high strain rates. The relation effective for this branch is

$$\dot{\epsilon} = A(\sigma_f/N)^M \tag{4}$$

where A is a temperature dependent rate parameter, σ_f is the effective stress, N is an anelastic modulus and M is a constant. The relation effective at an intermediate region where both mechanisms contribute significantly to the deformation is [8]

$$\sigma = \sigma_f + \sigma_a. \tag{5}$$

In the following analysis, the time derivative of strain, which was used in the $\log\sigma$–$\log\dot{\epsilon}$ plot, was obtained following the five points approximation

$$\dot{\epsilon}_3 = \dot{\sigma}_3/K = (\sigma_1 - 8\sigma_2 + 8\sigma_4 - \sigma_5)/12h \tag{6}$$

where K is the elastic stiffness of specimen plus testing machine, h is the interval of two successive measurements, σ_i is the stress rate and $\dot{\epsilon}_i$ is the strain rate at time t_i. More than 200 data points were used in order to draw a single $\log\sigma$–$\log\dot{\epsilon}$ plot. However, for the sake of simplicity, only some representative points are shown in Fig. 1. The parameters in Equations 2, 3 and 4 were determined using a least square method with a computer. For example, $\sigma^* = 1.107 \times 10^7$ Pa, $\dot{\epsilon}^* = 0.325 \times 10^{-13}\,\text{sec}^{-1}$ and $\lambda = 0.118$ for 9.2% strain at 20° C.

Typical $\log\sigma$–$\log\dot{\epsilon}$ data at various strain levels for high purity KCl at 20° C are shown in Fig. 1. All the curves concave upwards indicating that KCl at 20° C belongs to the high homologous temperature region in Hart's theory. The scaling relation is shown in the figure by an arrow, the slope of which is $\mu = 0.31$. If one of the $\log\sigma$–$\log\dot{\epsilon}$ curves is translated along the line, it is possible to overlap it with any one of the others. The inverse of the slope of the line, 1/0.31, is the parameter m in Equation 3 and is expected to equal the stress exponent from creep experiments of KCl. In this respect, Cannon and Sherby [9] have obtained $m = 5.0$ for polycrystalline KCl at 600° C, while for KCl–NaCl solid solutions they obtained $m = 2.4$ to 3.4. They discussed their results in terms of Weetman's classification [10] such that there are two types of solid solution alloys; (I) those with $m = 3.0$ which behave differently from pure metals, and (II) those with $m = 5.0$ which behave similarly to pure metals. According to Weetman, creep may be controlled by dislocation glide in class I alloys, while in class II alloys it may be controlled by dislocation climb or by the non-conservative motion of jogs in screw dislocations.

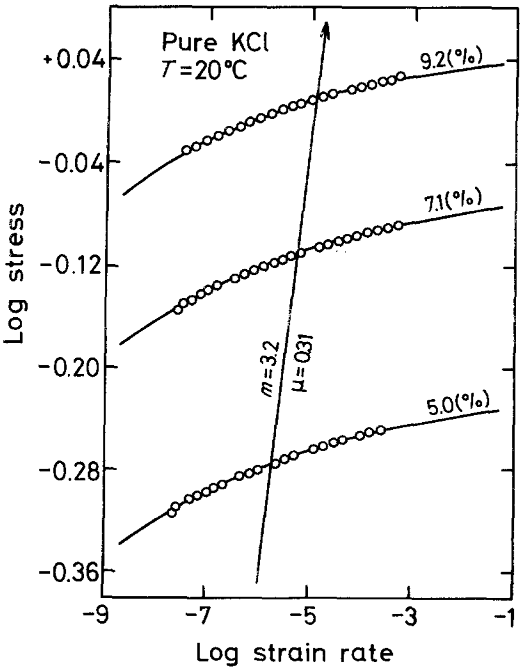

Figure 1 $\log\sigma$ against $\log\dot{\epsilon}$ data for KCl at several plastic strain levels. Measurements were made at 20° C.

Therefore, from the suggestions given by Hart [6] that at high homologous temperature regions the strong and localized resistance offered by second phase particles and dislocations of other slip systems intersecting the glide plane may be effective, the behaviour expected of class II alloys is more plausible in the high homologous temperature region. This seems to disagree with Weetman, since our result was $m = 3.2$.

Hart also suggested that the strong obstacles effective in the high homologous temperature region are dispersed in groups and cell walls with intervening zones of good crystal [6]. This kind of cell wall which acts as an effective site for blocking and annihilation of dislocations by climb have been observed by Poirier [11] and Pontikis and Poirier [12]. They deformed NaCl and AgCl at relatively high temperatures where the high temperature branch of the Hart model applies.

According to their results, the obstacles are dislocation assemblies, the mean size of their networks changes depending on the applied stress and temperature. This change in the dislocation substructure during stress relaxation may cause the invalidation of the basic assumptions (i.e. the constancy of the moving dislocation density and the internal stress during the test) for the introduction of Equation 1 [1, 2]. This is considered to be the reason why the stress relaxation of our KCl single crystal cannot be described by Equation 1.

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