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Influence of Hydrostatic Pressure of the Flow Stress in Polycrystalline NaCl

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Abstract

By etch-pitting NaCl polycrystals which had been subjected to a hydrostatic pressure of 8 or 10 kbar it was established that dislocations are generated *during* the pressurization treatment. The effect of these freshly nucleated dislocations on the stress–strain relationship at atmospheric pressure is established and the relevance of these observations to the interpretations of experiments carried out under pressure is discussed.

Aladag, Davis and Gordon (1970) have recently reported that the yield stress of polycrystalline sodium chloride is reduced by about 20% if the specimen is tested under a hydrostatic pressure of 10 kbar. Their material was ' seasoned ' at 10 kbar and then some specimens were compressed at atmospheric pressure whilst others were tested under pressure; results on unpressurized material were not reported. Aladag *et al.* attributed the difference in behaviour to increased ease of cross-slip at high pressure and did not consider the possibility of irreversible effects of the pressurization on the mechanical properties of sodium chloride. As solids with the cubic structure have isotropic linear compressibilities, local shear stresses should not be *expected* in the presence of grain boundaries on the application of hydrostatic pressure. It has, however, been demonstrated (Evans, Redfern and Wronski 1970) that dislocations are generated in the region of a tilt boundary in a bicrystal of NaCl subjected to a hydrostatic pressure of 10 kbar. It was accordingly decided to extend this investigation to NaCl polycrystals.

The specimens, of approximately square cross section ~10 mm high, were sectioned from polycrystalline AnalaR grade NaCl. Details of the experimental techniques have been previously reported (Evans *et al.* 1970). The total cation and anion impurity concentration was $\langle 20$ p.p.m., which precludes the presence of precipitates and pre-precipitates. The grain sizes were not uniform, the average grain diameters being ~1 mm. Pressurizations were carried out at 8 and 10 kbar and compression testing on a modified Hounsfield tensometer at strain rates of $\sim 2 \times 10^{-4}$ sec^{-1} at atmospheric temperature and pressure. Etch-pitting experiments

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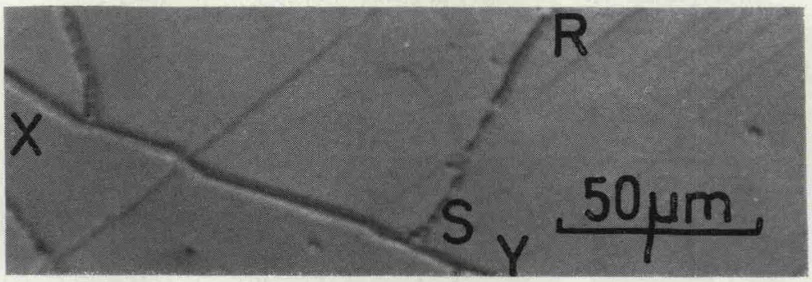
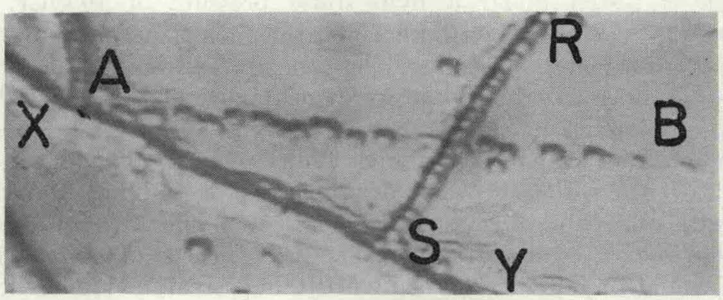
revealed that dislocations were generated, sometimes in well-defined ⟨110⟩ slip bands, near high angle boundaries whilst the specimens were subjected to the high hydrostatic pressure. Figure 1 illustrates a detail from a polycrystalline sample, where a {100} face has been etched before and after pressurization at 8 kbar. The edge dislocation etch-pit trace, AB, should be noted in particular; this motion arises, we suggest, from shear stresses developed from the grain boundary, XY.

Fig. 1



(*a*)



(*b*)

A {100} face of a NaCl polycrystal (*a*) before and (*b*) after pressurization at 8 kbar. In (*b*) note the line of screw dislocation etch pits AB, in ⟨100⟩, associated with the grain boundary XSY following the pressurization and crossing the sub-boundary RS.

Such a generation and motion of dislocations betoken a significant shear stress operating on the {110} planes in the sample interior. This stress must inevitably be in excess of 5–10 bar, which is the range of experimentally observed, critically resolved shear stresses in single crystals of similar purity.

The authors consider that these features of the pressurization treatment of NaCl samples have some significance in the discussion of the results of Aladag *et al.* (1970) on polycrystalline NaCl. We suggest that their