AUTE-TA 73-0441

Reprinted from
PHILOSOPHICAL MAGAZINE, Vol. 28, No. 2, p. 335, August 1973

Hydrostatic pressure and the mechanical properties of NaCl polycrystals

By T. A. AUTEN, L. A. DAVIS† and R. B. GORDON
Department of Geology and Geophysics, Yale University, New Haven, Connecticut 06520, U.S.A.

[Received 19 January 1973 and in revised form 16 March 1973]

ABSTRACT

The influence of hydrostatic pressure on the mechanical properties of extrusion-recrystallized NaCl polycrystals is examined. Interrupted compression tests show no effect of pressurization alone on the flow stress of these polycrystals. Small decreases in the flow stress occur upon reloading the specimen, regardless of the pressurization treatments, and are attributed to recovery between tests. These results, which are in contrast with reported tests on melt-grown polycrystals, show that the decrease in strength observed for polycrystals deformed in situ at 10 kbar, relative to those deformed at 1 atm, is not due to an increased density of mobile dislocations caused by pressurization alone.

§ 1. INTRODUCTION

Aladag, Davis and Gordon (1970) have observed a 15 to 30% decrease in the flow stress (at 2 to 4% compression) of NaCl polycrystals deformed continuously under a superposed hydrostatic pressure of 10 kbar, compared to that observed at 1 atm. During interrupted compression tests, with intervening pressurization treatments, Evans, Redfern and Wronski (1971 a) observed a decrease of $\sim 11\%$ of the flow stress necessary to reinitiate deformation (always at 1 atm) of NaCl polycrystals deforming in about the same strain regime. These authors also observed (Evans *et al.* 1970, 1971 a) by etch pitting techniques, an increase in dislocation density, occurring preferentially near high-angle boundaries in melt-grown bicrystals and polycrystals of NaCl subjected to soaking at high pressure.

The generation of dislocations near grain boundaries by hydrostatic pressure-induced shear stresses is to be expected in polycrystalline samples of materials having anisotropic compressibility (Andrews and Radcliffe 1967), such as Zn and Be. In the case of polycrystalline NaCl, however, which has isotropic compressibility, no local shear stresses and hence no dislocations should be generated under hydrostatic pressure in the void- and precipitate-free material. The etch pitting results of Evans *et al.* are thus unexpected (assuming the above conditions obtain) and at present

† Permanent address : Materials Research Centre, Allied Chemical Corporation, Morristown, N.J., 07960, U.S.A.

DEC 10 1973

unexplained. Nevertheless, on the basis of these results Evans *et al.* (1971 a, b) assert that the reduced flow stress observed at high pressure by Aladag *et al.* and the reduced flow stress observed in their own interrupted tests probably result from the pressurization treatment alone, i.e. that they derive from a pressure-induced increase in the density of mobile dislocations. To pursue this question further the present authors have conducted further deformation tests on polycrystalline NaCl, the results of which are reported below.

§ 2. Experimental procedure

R. J. Stokes of the Honeywell Research Center generously contributed additional void-free NaCl polycrystals produced by recrystallization of high-purity single crystals extruded through a circular die held at about 350°C (Stokes and Li 1963). Specimens about 8 mm in length are cut from rods 4 mm in diameter with a low-speed diamond saw, and the cut ends are ground parallel by cementing the specimens in a vee-block and lapping them on abrasive paper. Then the specimens are briefly polished in water and rinsed in methanol and ether. The average grain diameter is 0·1 to 0·2 mm. Compression tests are performed with the minitester (a constant-speed compression tester described by Davis and Gordon (1968)) positioned inside the pressure chamber for both 1 atm and 10 kbar pressure tests, permitting the interrupted tests to be done without removing the specimen at each step. Other experimental conditions are identical with those of Aladag *et al.*; compression rate of 10^{-4} sec^{-1}, room temperature, *n*-pentane as pressure fluid, and unjacketed specimens.

§ 3. Results

Figure 1 shows nominal stress-compression curves for polycrystalline NaCl samples deformed at 1 atm and 10 kbar; these specimens were not 'seasoned' by pressure-soaking prior to testing as had been the case for the samples tested by Aladag *et al.* This figure confirms the earlier result of Aladag *et al.* and shows that the observed reduced flow stress of samples deformed at 10 kbar does not depend on a soaking cycle. The relative magnitude of the decrease in flow stress is somewhat reduced in the present results, as shown in the table; we note that the present specimen material is of larger grain size (0·22 mm versus 0·10 mm for Aladag *et al.*)

Reduced flow stress, compared to 1 atm values, observed during *in situ* deformation at 10 kbar

Compressive strain (%)	2	3	4	5	10
Decrease in flow stress :					
Aladag *et al.*	20–24%	19–27	15–22	16–20	14
Present work	10	13	13	13	12