Fig. 4—Grain E_2 sample Zn-15 after exposure to 11.86 kbars. Polarized light; X48. Reduced approximately 47 pct for reproduction.

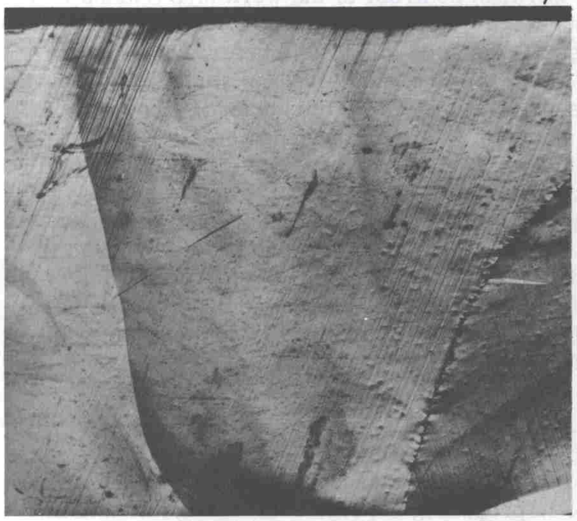

Fig. 5—Grain E_2 sample Zn-15 after exposure to 26.91 kbars. Polarized light; X48. Reduced approximately 43 pct for reproduction.

as has previously been noted,[15] is rather indistinct, Fig. 7, but they are more readily seen with the aid of phase-contrast metallography as shown in Fig. 8. $\{11\bar{2}2\}$ slip was seen in almost all grains whose surface normals were close to the $\langle 0001 \rangle$ direction as is illustrated in Fig. 1. In these orientations the intensity of basal-slip lines is relatively small and so would not be expected to interfere with the viewing of other slip lines. It is more than likely that $\{11\bar{2}2\}$ slip has taken place in many more of the grains, but interference by basal-plane slip traces has prevented general observation of the pyramidal-plane slip traces.

Other more complex deformation behavior has been observed in these experiments. Fig. 9 illustrates one such region, grain B_1 of sample Zn-15, after exposure to ~27 kbars. The central region located approximately halfway between the grain boundaries (not shown) has been reduced in dimension substantially, whereas the dimensions of the region near the left and right of the photograph, close to the grain boundaries,

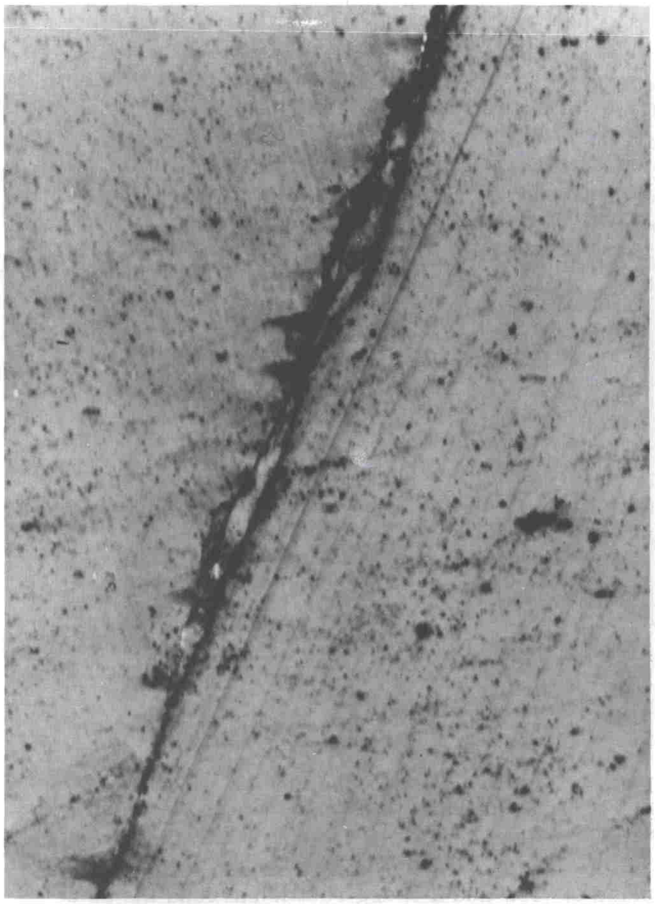

Fig. 6—Grain boundary between grains D_2 and E_2 sample Zn-15 after exposure to 26.91 kbars. Polarized light; X600. Reduced approximately 18 pct for reproduction.

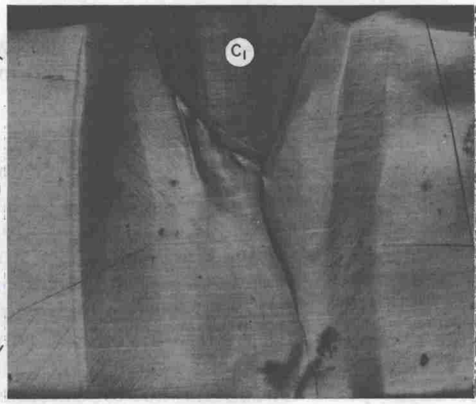

Fig. 7—Grains B_1, C_1, and D_1 sample Zn-14 after exposure to 24.78 kbars. Polarized light; X48. Reduced approximately 53 pct for reproduction.

have remained unchanged. The basal planes whose traces form a kinklike pattern are nearly perpendicular to the plane of view. To ascertain the orientation shifts involved in the different regions of the grain, Laue back-reflection X-ray patterns were taken in the various numbered regions and compared to the original orientation. In Region 1 the orientation change involves a 15-deg rotation about a $\langle 10\bar{1}0 \rangle$ direction lying in the plane of view and parallel to the basal slip trace. In Region 2 the major orientation change can be described by a rotation of 15 deg around a normal to the

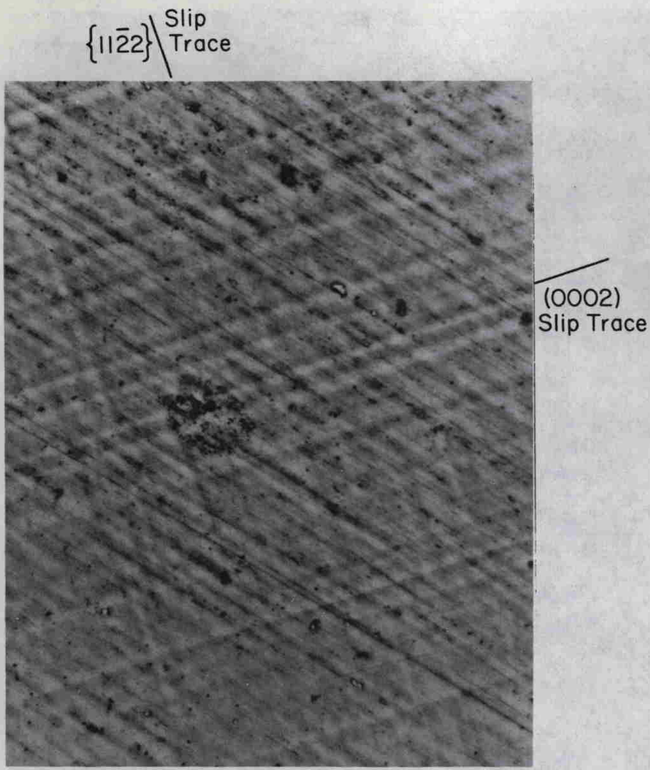

Fig. 8—Grain D_1 sample Zn-14 after exposure to 24.78 kbars. Phase contrast; X937. Other traces are polishing scratches. Reduced approximately 34 pct for reproduction.

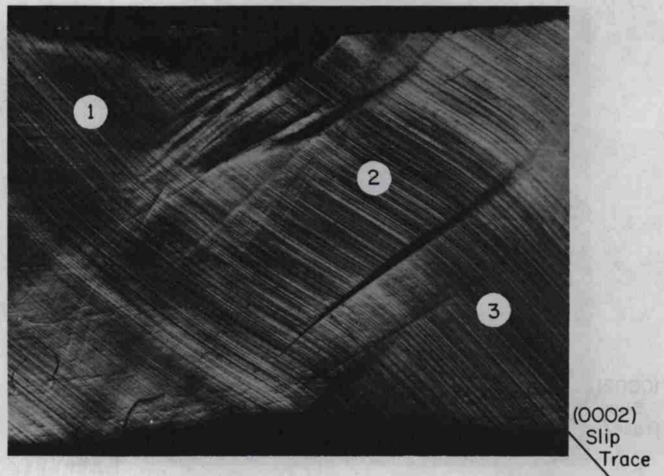

Fig. 9—Grain B_1 sample Zn-15 after exposure to 26.91 kbars. Polarized light; X48. Reduced approximately 45 pct for reproduction.

plane of view and a 5-deg rotation around the same axis as in Region 1. The orientation of Region 3 is essentially unchanged from its original one; however, the Laue pattern shows a large amount of asterism demonstrating the inhomogeneous deformation. The analysis of the mechanism of formation of such complex structures is complicated by a lack of knowledge of the stresses induced by the neighboring grains.

DISCUSSION

No entirely new deformation modes have been induced in zinc by exposure to a high hydrostatic pressure environment. All have been seen before in zinc deformed at atmospheric pressure. This does not however rule out the possibility that deformation by means of $\{11\bar{2}2\}$ slip is made easier relative to (0002) slip at high pressure as would be predicted from Eq. [1]. In fact, the evidence that $\{11\bar{2}2\}$ slip is observed whenever basal-plane traces are not too intense, *i.e.*, when the normal to the observed surface is close to $\langle 0001 \rangle$, gives some support to this hypothesis, see Fig. 1(*b*).

The observations are not at variance with Pugh's idea that the enhanced ductility of zinc under high pressure is based on a critical tensile stress criterion for fracture.[16] The application of a hydrostatic pressure could thus prevent the nucleation and/or growth of cracks and allow the shear-stress level to become higher. This in turn might allow more systems to enter into the deformation process. Measurements on single crystals of the stress levels to activate the different deformation processes should provide an answer as to which of the aforementioned processes is more important.

No evidence of grain boundary sliding was detected in this work, in contrast to the work of Davidson *et al.*[3] This may be due to the fact that Davidson held his samples at pressure for 30 min before pressure release, whereas the samples in this study were brought to pressure and immediately released. Another possible important factor is the much smaller grain size of Davidson's samples or possible differences in chemical composition.

Recrystallization near some of the grain boundaries after exposure to the highest pressure used in this study (27 kbars) offers means for relaxation of stress in polycrystalline zinc in addition to the more usual (0002), $\{11\bar{2}2\}$ slip, $\{10\bar{1}2\}$ twinning, and bend-plane formation.

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