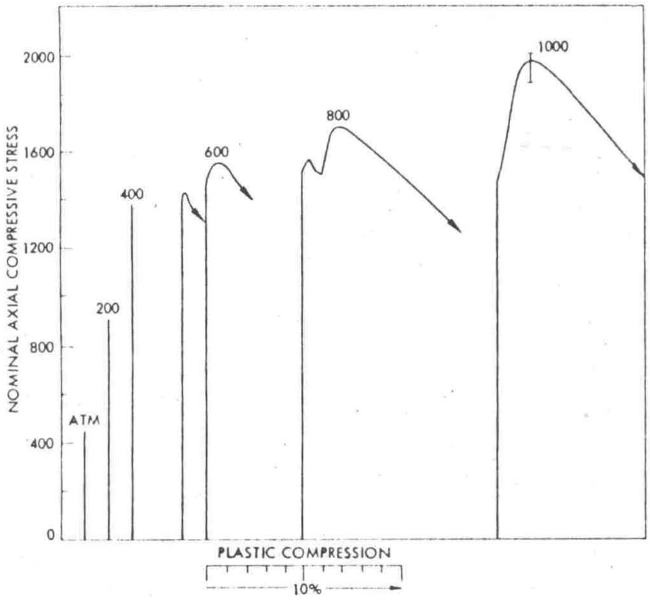


**Fig. 1. Plots of stress vs plastic strain produced by uniaxial compression of vacuum-hot-pressed MgO polycrystals without jackets. Test pressures (in MPa) are indicated by numerals above curves. Vertical lines for tests at lower pressures correspond to simple elastic loading followed by catastrophic collapse, whereas tests at higher pressures exhibited "plastic" deformation and gradual collapse (the latter indicated by *arrows*).**

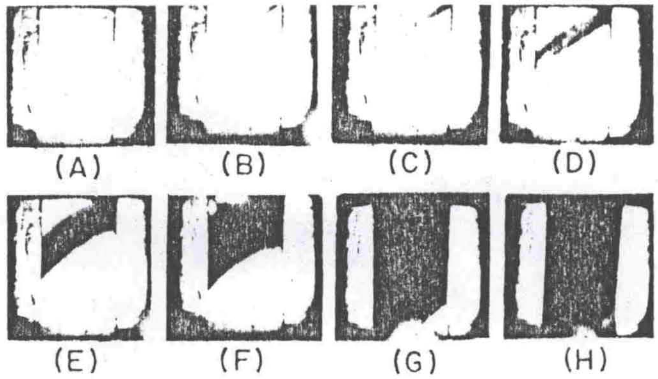


**Fig. 2. Transmitted light images of polycrystalline MgO taken during compression test at chamber pressure of 1000 MPa. (*A*) First crack appeared at 1450 MPa, and (*B*) second crack develops. (*C*) and (*D*) As nonlinear loading occurs, cracks propagate past each other at ≈1520 MPa. (*E*)–(*H*) As curve decreases slightly and develops horizontally, the image becomes opaque. Work-hardening began just after image (*H*).**

Figure 2 shows a progression of images photographed during the compression of a specimen at a chamber pressure of 1000 MPa. The progressions observed for various specimens changed with chamber pressure, but the images characteristic of a given pressure can be represented by some of those observed at 1000 MPa.

At a chamber pressure of 200 MPa, specimens exhibited small zones of gray contrast on inclined planes (similar to that shown in Fig. 2(*A*), upper right corner) at the maximum applied compressive stress, 900 MPa. Instantaneously after that, the load decreased catastrophically, accompanied by a rapid blackening of the image (as in Fig. 2(*G*)) and collapse of the specimen.

The nature of the contrast found in these images was studied by deforming a specimen at high pressure until a contrast similar to that shown in Fig. 2(*C*) developed, then the test was interrupted and the specimen removed. The portions of the specimen that exhibited contrast during the test were zones of intergranular cracks, whereas the portions remaining transparent were free of cracks. This behavior suggests that the contrast was the result of cracking; similar observations on every specimen recovered from direct observation tests reinforced this suggestion. Other phenomena may have caused the contrast in transmitted light; surface relief, e.g. that found in compression tests on jacketed MgO single crystals at various pressures,[13] could produce contrast when sufficiently pronounced. Indeed, in the course of the present work, specimens with surface relief resulting from irregularities in chemical polishing showed faintly observable contrast, but such contrast was distinguished by its unusual wave-like appearance and its presence prior to loading. No heavy surface relief resulting from plastic deformation was found in any of the polycrystals of the present work. Another possible source of contrast would be internal plastic deformation, but such contrast requires the use of a polarized light source, which had not been built into the optical system. Since none of these alternate models can explain the contrast in Fig. 2, it is concluded that the gray and black areas developed in the specimens during testing result from the presence of internal cracks. Such a conclusion is consistent with high-temperature compression test results in which loss of transparency in MgO polycrystals is attributed to the separation of grain boundaries.[11]

At a chamber pressure of 400 MPa, the cracking progression was similar to that at 200 MPa. The first crack appeared at 1310 MPa, before the ultimate stress of 1380 MPa. By the time the ultimate stress was reached, thin cracks had propagated across the specimen on ≈45° planes. Coincident with the rapid decrease in load, the specimen blackened, and during the release of pressure, the black portion swelled slightly and collapsed in spite of the absence of any applied uniaxial compressive stress.

The general progression of images seen in a 600-MPa test differed slightly from those at lower pressures. Typically the first crack appeared at 1200 to 1500 MPa in the linear portion of the stress-strain curve. As the nonlinear part developed, the crack continued slow propagation along a 45° plane until, at the peak stress of 1500 to 1600 MPa, the crack was halfway across the specimen. A rapid decrease in load then occurred, accompanied by the rapid spreading of black contrast across $^{2}/_{3}$ of the specimen length. After that, the compressive stress diminished at a relatively slow rate to 1450 MPa, coinciding with a halt in the spread of the black contrast. Then the load continued to decrease at a slower rate, and the black contrast slowly continued spreading.

At 800 MPa chamber pressure, the images were similar to those at 600 MPa (and to those in Fig. 2(*A*) to 2(*D*)), with the first crack appearing during the linear behavior at a uniaxial load of 1520 MPa. However, an apparent upper yield point occurred after that, and as the load decreased, the specimen turned black by a progression of instantaneous, discrete steps in bands at 45° to the loading axis. Once the opacity had spread through the entire length, the stress started to increase, reaching a maximum of ≈1650 MPa, followed by a gradual decline, as shown in Fig. 1. At 1000 MPa chamber pressure, the progression of images was similar (of course, identical with the images in Fig. 2), but the slow blackening of the specimen coincided with either very small decreases in flow stress or mere inflections of the original linear elastic curves (see Fig. 1).

These observations demonstrate that cracking played a major role in both early and late stages of the deformation process. Also, increased pressure led to changes in the deformation behavior associated with the various modes of cracking. At ≤400 MPa, the rate of crack propagation in the linear loading range was slow and, in the final stage, catastrophic; but at higher pressures, catastrophic cracking did not occur, suggesting that increased pressure causes a transition in mechanical behavior by affecting crack propagation rates. There appears to be a difference in the type of cracks propagating in various types of stress-strain curves, as seen in the light and opaque contrasts corresponding to different parts of the stress-strain curves. To determine the nature of cracking in each stage of the curves, the specimens which were recovered from both interrupted and completed tests were examined with optical microscopy and SEM.

### (3) *Morphology of Deformed Specimens*

The specimens obtained from atmospheric compression tests were split longitudinally by intergranular cracks into several frag-