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Polycrystalline solids under nonhydrostatic compression: Determination of strength from x-ray diffraction data

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A polycrystalline sample compressed in a diamond anvil cell (DAC) without any pressure transmitting medium develops a stress state at the center of the sample that is axially symmetric about the load axis. The axial stress component is larger than the radial component and the difference between the two is taken as a measure of compressive strength of the sample material at a confining pressure that equals the mean normal stress. The diffraction data taken from a sample under such a stress sate contain a range of information that is absent in the hydrostatic pressure data. A proper analysis of the data using the lattice strain theory yields compressive strength. The data taken with the radial diffraction geometry wherein the incident x-ray beam is perpendicular to the load axis of the DAC gives reliable estimates of strength. The diffraction data obtained with the conventional geometry wherein the incident x-ray beam passes parallel to the DAC axis are not suitable for a full range of analysis. However, reliable estimates of the strength can be obtained by combining the measured pressure-volume data under nonhydrostatic compression and the hydrostat derived from an independent source. The broadening of diffraction lines under nonhydrostatic compression has been also used to estimate the strength of crystalline solids. The effect of elasto-plastic deformation on the strength estimates will be discussed.