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Impact of the uniaxial compression on the stress tensor and lattice parameters in magnetite

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In this study, we investigate the effect of symmetry breaking induced by uniaxial pressure on the structural properties of stoichiometric magnetite at room temperature. To this end, we present the XRD measurements performed on a single crystal of magnetite under systematically increasing, externally applied uniaxial stress. The uniaxial compression was applied using the commercially available mechanical press manufactured by ADMET.

To accommodate a sample shaped as a rectangular brick of 2.5 mm in length and a cross section of 1 mm2, a custom steel chamber was designed, incorporating two ceramic sample-holding posts (see Fig. 1a). As shown in Fig. 1b, a specimen oriented in the [100] direction was glued to the adapter and subjected to uniaxial compression with the parallel XRD measurement. Analysis of the obtained diffraction pattern enabled the determination of both the lattice parameters and the stress tensor in the laboratory and reference coordinate frames.

As shown in Fig. 1c, uniaxial compression results in a concurrent elongation of the lattice parameter in the [100] and [010] directions, accompanied by a contraction along the [001] direction. Moreover, an applied uniaxial compression of 100 MPa lead to a deviation of the α lattice angle from 90° by 0.05°.

For each level of applied compression, the corresponding stress tensor was determined in both the laboratory and reference coordinate frames. From these tensors, the Young's modulus was determined, yielding values within the broad range of 60-195 GPa, consistent with the previously reported literature data.

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