Oxidative dissolution induced strain and defects in magnetite nanocrystals

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Oxidation of magnetite (Fe_3O_4) is a critical reaction in (bio-)geochemistry, environmental science and materials science. Challenges on spatially resolving partially oxidized magnetite domains of various stoichiometries and associated strain stemmed from lattice contraction have hindered further understating on its oxidation mechanism. Here we show that the morphology and strain evolution during oxidation of individual magnetite nanocrystal can be visualized in three-dimension using Bragg coherent diffractive imaging (BCDI). Increasing magnitude and heterogeneity on strain and appearance/disappearance of dislocation defects were observed during the oxidative dissolution of magnetite in acidic solutions. Fe(II)-deficient and Fe(II)-rich domains were likely correlated with the observed compressive and tensile strains, respectively. The results demonstrate that oxidative dissolution of magnetite in aqueous environment can induce a rich array of strain and defect structures, which may have significant impacts on a broad range of geochemical reactions occurring on magnetite.