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Magnetite plaquettes are naturally asymmetric materials in meteorites

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Abstract

Life on Earth shows preference toward the set of organics with particular spatial configurations. Enantiomeric excesses have been observed for α-methyl amino acids in meteorites, which suggests that chiral asymmetry might have an abiotic origin. A possible abiotic mechanism that could produce chiral asymmetry in meteoritic amino acids is their formation under the influence of asymmetric catalysts, as mineral crystallization can produce spatially asymmetric structures. Although magnetite plaquettes have been proposed to be a possible candidate for an asymmetric catalyst, based on the suggestion that they have a spiral structure, a comprehensive description of their morphology and interpretation of the mechanism associated with symmetry-breaking in biomolecules remain elusive. Here we report observations of magnetite plaquettes in carbonaceous chondrites (CC) that were made with scanning electron microscopy and synchrotron X-ray computed microtomography (SXRCT). We obtained the crystal orientation of the plaquettes using electron backscatter diffraction (EBSD) analysis. SXRCT permits visualization of the internal features of the plaquettes. It provides an unambiguous conclusion that the plaquettes are devoid of a spiral feature and, rather that they are stacks of individual magnetite disks that do not join to form a continuous spiral. Despite the lack of spiral features, our EBSD data show significant changes in crystal orientation between adjacent magnetite disks. The magnetite disks are displaced in a consistent relative direction that lead to an overall crystallographic rotational mechanism. This work offers an explicit understanding of the structures of magnetite plaquettes in CC, which provides a fundamental basis for future interpretation of the proposed symmetry-breaking mechanism.

Keywords: Magnetite, plaquettes, carbonaceous chondrites, symmetry-breaking, scanning electron microscopy, SEM, electron backscatter diffraction, EBSD, synchrotron X-ray computed microtomography, SXRCT, aqueous alteration, crystal structure