MAGNETITE PLAQUETTES PROVIDE AN EXTRATERRESTRIAL SOURCE OF ASYMMETRIC COMPONENTS.

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Introduction: Molecular selectivity is a crucial criterion for life. A possible abiotic mechanism that can produce chiral asymmetry in meteoritic amino acids is their formation with the presence of asymmetric catalysts [1, 2]. Magnetite (Fe_3O_4), a common mineral in some carbonaceous chondrites (CCs), has been shown to be an effective catalyst for the formation of amino acids that are commonly found in these meteorites [3]. Magnetite sometimes takes the form of plaquettes that consist of barrel-shaped stacks of magnetite disks that resemble a spiral [4]. However, a widely accepted description of the internal morphology of this particular magnetite form is still lacking, which is necessary in order to confirm or disprove the spiral configuration.

Analytical methods: We analyzed polished thin sections of fifteen CCs spanning different classes. Imaging and mineral elemental compositions were obtained using the JEOL 7600F Field Emission scanning electron microscope (SEM) at NASA Johnson Space Center (JSC). Electron backscattered diffraction (EBSD) patterns were obtained using a Zeiss SUPRA 55VP Field Emission SEM with a Bruker Quantax CrystAlign 400i EBSD system coupled with a Bruker e^-Flash EBSD detector at JSC.

Results and Discussion: Magnetite plaquettes were observed in nine (Alais, Ivuna, Orgueil, LAP 02422, GRO 95577, GRA 95229, Renazzo, PCA 91467, and Bench Crater) out of fifteen CCs analyzed. We can summarize that the approximate, observed abundance of magnetite plaquettes follows the sequence of CI1 > CR2 > CR1 > CM1 ≥ CH3, while we did not locate magnetite plaquettes in CM2, CO3, or CV3.

Spiral vs non-spiral features. Some magnetites appear to display a “spiral” appearance. However, these are most likely laboratory-induced features caused by mechanical polishing during thin section preparation. Several plaquettes clearly show that the surfaces of the terminating plates are smooth and are clearly devoid of a spiral feature. These plates are either tilted sideway or protected by adjacent features so that the surfaces were not susceptible to the polishing effect, and thus they should represent the original morphology.

EBSD analysis. According to the EBSD data, the crystal orientation is fairly consistent within a single magnetite disc. The crystal orientation changes less than 6° in a disc, which reveals that the magnetite disc was formed as a single crystal with one preferred crystal orientation.

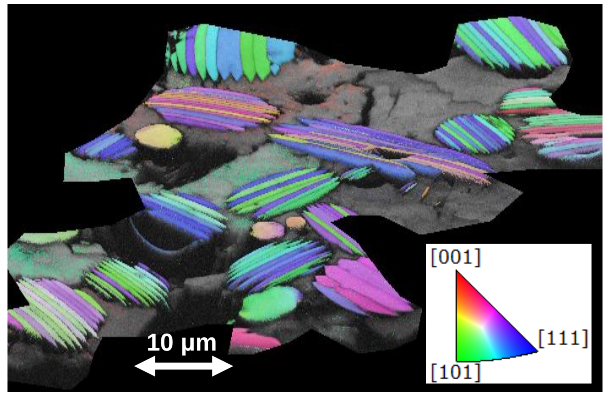

Figure 1. EBSD inverse pole figure (IPF) map of a cluster of magnetite plaquettes in Orgueil. The insert shows the IPF map legend.

Notable changes in crystal orientation are observed between adjacent magnetite discs. Therefore, although individual discs are not connected and no explicit spiral morphology was observed, variation in crystal orientation across the magnetite stack still provides a mechanism for a rotational relationship. As we could observe changes in crystal orientation along the magnetite stack, we were also able to reconstruct the rotation orientation by observing the misorientation direction relative to the adjacent discs, in order to see if the rotation is consistent with a preferred direction. In general, magnetite stacks appear to be comprised of several groups of discs with consistent rotation direction within the group. Magnetite growth appears to have reset at various time intervals, which is represented by notable shifts in crystal orientation between adjacent disks.

Conclusions: We conclude that magnetite plaquettes are in reality stacks of individual discs, with crystal orientation changing significantly along the stack. Our future direction is to observe the internal morphology of magnetite plaquettes by X-ray computer tomography, and characterization of the magnetic structure of plaquettes using magnetic force microscopy, to determine whether the rotation between adjacent plates within plaquettes can influence organic chirality.

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