

**MAGNETITE SURFACE PROVIDES PREBIOTIC HOMOCHIRAL SELECTIVITY.**

Q. H. S. Chan<sup>1</sup>, M. E. Zolensky<sup>1</sup>, A. Tsuchiyama<sup>2</sup> and J. E. Martinez<sup>3</sup>. <sup>1</sup>ARES, NASA Johnson Space Center, Houston, TX 77058, USA, E-mail: [hschan@nasa.gov](mailto:hschan@nasa.gov). <sup>2</sup>Graduate School of Science, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan. <sup>3</sup>Jacobs Engineering, Houston, TX 77058, USA.

**Introduction:** Magnetite is a well-known oxide mineral occur in most carbonaceous chondrites. It has been shown to be an effective catalyst for the formation of amino acids (AA) that are commonly found in these meteorites [1]. Magnetite in meteorites can sometimes take the form as plaquettes, which are stacks of individual discs with consistent change in crystal orientation that manifests a rotational feature [2]. As biology shows unequivocal homochirality for chiral organics, possible prebiotic mechanisms that can produce chiral selectivity are being extensively evaluated. In this study, we show how magnetite plaquettes may play a role in influencing the selection of AA chirality.

**Methods:** We obtained the electron backscattered diffraction patterns of magnetite plaquettes in Orgueil using a Field Emission scanning electron microscope coupled with an EBSD detector at NASA JSC. We removed focused ion beam sections of magnetite plaquettes at Kyoto University, which were then studied by X-ray computed microtomography at SPring-8 (Japan) to reveal the internal morphology of the plaquettes.

**Results and Discussion:** Misorientation can be expressed by a rotation axis and rotation angle ( $\theta$ ). The rotation axis of magnetite plaquettes is generally perpendicular to the planar surface of the magnetite discs, so that the discs resemble a deck of cards that rotates about a common axis penetrating through the center of the deck. Magnetite has a high crystal symmetry as it is belong to the cubic spinel space group. Under this geometry, the maximum observed  $\theta$  is  $45^\circ$ , because any greater rotation is equivalent to a smaller rotation in the opposite direction. Thus,  $\theta$  is conventionally represented by the minimum angle (i.e. disorientation) [3]. The observed  $\theta$  spans the range from  $0-45^\circ$  but preferentially occurs  $<10^\circ$  and  $>40^\circ$ . The plaquettes are comprised of discs with fairly consistent rotation direction – counter-clockwise.

Magnetite plaquettes sometimes form doublets, where discs of different crystal orientations are drawn closer together and *vice versa*. The plate-doublets likely represent anti-aligned magnetization that results in charged interlayers, which can influence the binding of charged organics (e.g. zwitterion AA), through van der Waals interactions as suggested for the binding of nucleotides in montmorillonite [4]. Molecular dynamics simulations showed that AA and magnetite interaction is dominated by electrostatic forces between the surface  $\text{Fe}^{3+}$  and the O of the AA carboxyl group [5], therefore, plaquettes with rotation features can possibly influence molecular chirality specification by triggering an initial enantiomeric excess (*ee*) (i.e. positive correlation between plaquette size/shape/abundance and initial *ee*), which can be amplified to different extents by other processes on the parent body.

**References:** [1] Pizzarello S. 2012. *Meteoritics & Planetary Science* 47:1291-1296. [2] Chan Q.H.S. *et al.* 2015. Lunar and Planetary Science Conference. 1150. [3] Wheeler J. *et al.* 2001. *Contributions to Mineralogy and Petrology* 141:109-124. [4] Ferris J.P. 2006. *Philosophical Transactions of the Royal Society B: Biological Sciences* 361:1777-1786. [5] Bürger A. *et al.* 2013. *Journal of Molecular Modeling* 19:851-857.