PHOSPHORUS SPECIATION IN HYDROUS CARBONACEOUS METEORITES: INDICATIONS OF THE DEGREE OF OXIDATION DURING HYDROTHERMAL PROCESSING.

G. J. Flynn[1], S. Wirick[2] and P. Northrup[3], [1]SUNY-Plattsburgh, 101 Broad St., Plattsburgh, NY, 12901 (flynngj@plattsburgh.edu), [2]Focused Beam Enterprises, Westhampton, NY 11977, [3]Stony Brook University, Stony Brook NY 11794.

Introduction: We have begun a survey of the P speciation in hydrous carbonaceous chondrite meteorites using X-ray Absorption Near-Edge Structure (XANES) spectroscopy. XANES, an element-specific technique probing the local bonding state, is particularly useful to study element speciation at the microscale since it does not rely on the long-range order required for identification of a host mineral by diffraction. Phosphates in hydrous carbonaceous chondrite meteorites are believed to be secondary minerals, formed during parent body hydrothermal processing. Thus P speciation is expected to reflect the oxidation condition and composition of the fluid responsible for their deposition.

Samples and Procedure: Thus far, we have analyzed three hydrous C2 meteorite falls -– a polished section of the Murchison CM2, a flat, saw-cut surface of the Aguas Zarcas CM2, and a dry-polished section of the Tarda C2-ung. First, we mapped the P distribution by X-Ray Fluorescence (XRF) using the Tender Energy Spectrometer (TES) instrument on Beamline 8-BM at the National Synchrotron Light Source II (Brookhaven National Laboratory). We then performed P-XANES spectroscopy at each P hot-spot that had sufficient counts to allow good spectra.

Results and Discussion: In all three meteorites, the dominant P host was a phosphate mineral, with several spots having spectra consistent with Ca-apatite (Figure 1). However, some of the P hot-spots in each of the three meteorites had P-XANES spectra exhibiting both phosphate and phosphide, with some of the phosphides having spectra consistent with schreibersite (Figure 2). Since schreibersite is the first P host mineral to condense from a cooling gas of Solar composition, P was likely incorporated into these meteorites as phosphide. However, no pure phosphide grains were identified in any of the three meteorites, indicating that subsequent hydrothermal processing partially or completely converted the phosphide to phosphate. As noted by Fuchs [1], if phosphate minerals are in equilibrium with associated schreibersite, a relative degree of oxidation can be calculated for those meteorites that contain a particular phosphide-phosphate pair. Based on the largest ratio of the phosphide to the phosphate peak heights (Figure 2), Tarda showed the highest phosphide content, followed by Aguas Zarcas, and finally by Murchison.

Conclusions: These results suggest that P was incorporated into the parent bodies as phosphide, and that aqueous processing was most effective at oxidizing this phosphide to phosphate in Murchison, with a lesser degree of oxidation in Aguas Zarcas, and the least degree of oxidation in Tarda. In assessing the exogenous delivery of schreibersite, possibly an important source of P for the origin of life, to the early Earth, iron meteorites were favored because schreibersite is the dominant P host [2]. That work suggested that only ~1% of the P in carbonaceous chondrites is present in schreibersite [2]. However, our results show a significantly higher phosphide content in these C2 meteorites, especially Tarda and Aguas Zarcas. So accretion of schreibersite from meteorites like Tarda and Aguas Zacartas, or their dust, may have played an important role in prebiotic chemistry on Earth.

References: [1] L. H. Fuchs (1969). The Phosphate Mineralogy of Meteorites. In: Meteorite Research. Astrophys. Space Sci, Lib., vol 12. Springer, Dordrecht doi.org/10.1007/978-94-010-3411-1_56. [2] M. A. Pasek (2016) Schreibersite on the early earth, Geosci. Front., (2016) doi: 10.1016/j.gsf.2016.06.008A.

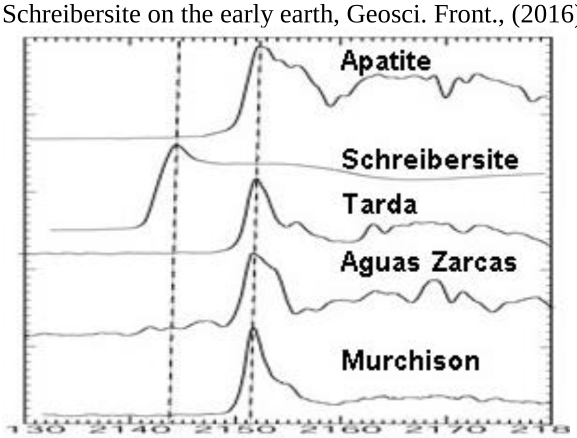

Figure 1: P-XANES spectra of P hot-spots showing only phosphate compared to phosphide (schreibersite) and phosphate (fluorapatite) standards.

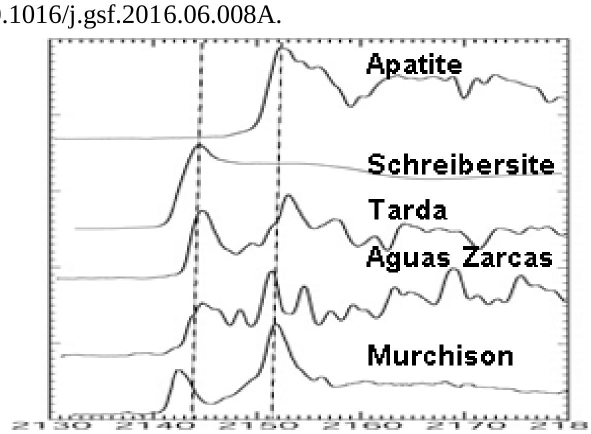

Figure 2: P-XANES spectra of P hot-spots showing a phosphide contribution compared to phosphide (schreibersite) and phosphate (fluorapatite).