

COMPLEMENTARY STXM AND CONFOCAL RAMAN IMAGING OF MURCHISON CM2 PARTICLE EMBEDDED IN SULFUR. M. Fries¹, A. Butterworth², C. Snead² and A. Steele¹. ¹Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Rd. NW, Washington, D.C. 20015, m.fries@gl.ciw.edu, ²University of California, Berkeley, 7 Gauss Way, Berkeley, CA 94720, annab@ssl.berkeley.edu .

Introduction: Scanning transmission X-ray microscopy (STXM) and confocal Raman imaging have been utilized on a sample of the Murchison CM2 meteorite in order to examine the structure and composition of carbonaceous material with a minimal degree of alteration due to sample preparation. The resulting complementary data set shows minute variation in carbonaceous material crystallinity proximal to a silicate portion of the sample, with sub-micron spatial resolution.

Description: A small fragment of Murchison CM2 carbonaceous chondrite was embedded in a small 0.5 mm diameter well of sulfur in the tip of an epoxy bullet and microtomed to produce thin sections (Figure 1). The method used was a modification to the standard sulfur embedding technique, in order to embed large (>20 μm) particles. A 0.5 mm hole was drilled into the top surface of an epoxy bullet. Sulfur was placed into the hole and melted. A 100- μm particle of crushed Murchison meteorite was placed in the molten sulfur, which was then cured by seeding with a small sulfur crystal. The sulfur bonded to the drilled surface quite well, eliminating the need to glue the sample. As is common. This technique produces microtomed thin sections suitable for STXM analysis without contamination by mounting polymers, since the sulfur is sublimed before analysis. Larger thin section areas also increase the probability of identifying a carbon-rich area of meteorite for carbon near-edge X-ray absorption fine structure (C-NEXAFS) analyses.

Phase identification and carbon structure analysis was performed using confocal Raman imaging of the potted butt in the epoxy bullet, and STXM/NEXAFS was performed on an adjoining microtomed thin section at Beamline 5.3.2 STXM, Advanced Lightsource, LBNL. Strengths of this sample preparation technique include the capability to add phase identification and carbon structure data from Raman analysis to carbon fine-scale mapping (<100 nm) and oxidation state data from STXM/NEXAFS. These measurements preferably should be the first analysis made a microtomed section to avoid damage to the carbon. The energy range of the soft X-ray source at ALS 5.3.2 STXM is 250 to 700 eV, optimized for C, N and O. Composition and structural context for the meteorite section must be made by complementary technique.

The microtomed surface is much less altered than a polished surface, allowing Raman imaging of the

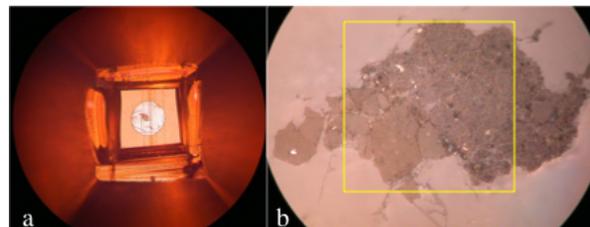


Figure 1: a) Epoxy bullet with 0.5 mm hole, containing sulfur embedded Murchison chip. b) Optical micrograph of Murchison remaining in the sulfur shortly after microtoming. The yellow square is (approximate) STXM/Raman map area.

structure of carbon exposed at the sample surface. Weaknesses include some uncertainty of data matching due to slight distortion of the microtomed section and the gradual loss of sulfur by sublimation, although the sample can be re-mounted by the same method if necessary.

Results and Discussion: Raman images show that this Murchison specimen is composed of olivine and pyroxene grains with adjoining carbonaceous material and is likely a fragment of a POP chondrule with matrix (Figure 2). The carbon G/D band intensity ratio, which is an expression of the crystallinity of carbon [1-3], shows a decided increase proximal to the silicate grains. This implies that the carbon was heated to a greater degree next to the silicates than in the matrix. Perhaps the best explanation for this is through accretion of carbonaceous matter onto a hot chondrule in the early stages of parent body accretion. Raman data from the olivine shows a trend from more fayalitic at the rim to more forsteritic moving away from the carbonaceous material. If the silicate portion is part of a chondrule, then this iron concentration trend can be explained as a fayalitic rim of a more forsteritic chondrule. Future studies using this sample preparation method will use materials with well-described petrographic setting in order to put these measurements in context.

Conclusions: The sample preparation method used here is especially useful in preparing surfaces with minimal alteration for Raman analysis, especially since previous studies have shown that polished surfaces on thin sections are essentially unusable due to mechanical alteration. Combination of phase identification by Raman analysis with STXM imaging is useful for pro-

ducing detailed mapping of carbon structure in very small samples.

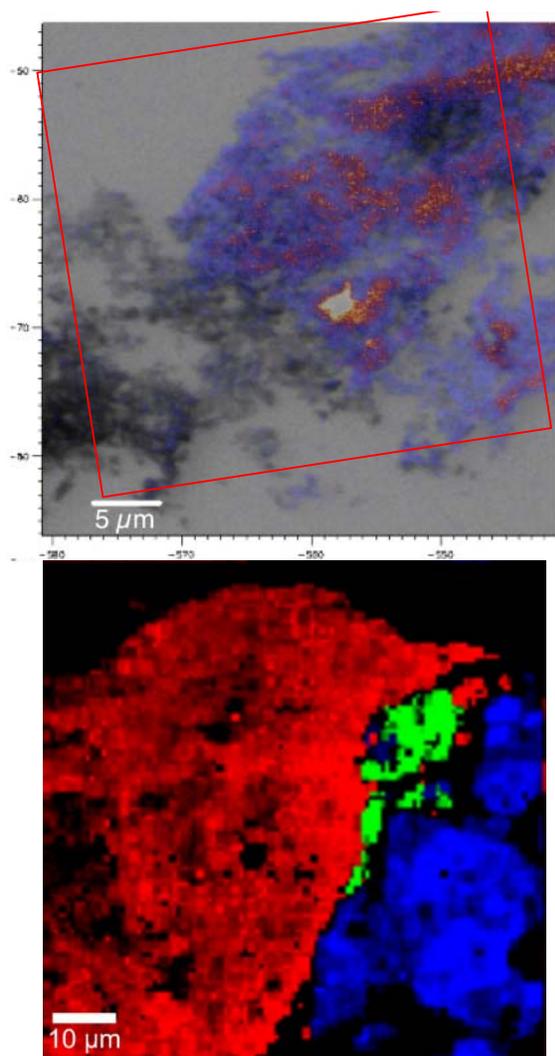


Figure 2) Upper Image: STXM carbon map from marked yellow area in Figure 1. Blue-red-yellow image is difference image 290-280 eV, with 100 nm lateral resolution. Grey underlying image is the same 280 eV, pre-C edge image. The red box is the approximate location of the Raman image below.

Lower Image: Raman RGB map, flipped horizontally to the STXM map and rotated slightly. R: Carbon G/D band intensity ratio (relative to crystalline domain size distribution in carbon) G: Pyroxene, and B: Olivine

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