INVESTIGATION OF CARBON IN THE ALLAN HILLS A77278 METEORITE.

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Introduction: Allan Hills A77278 (ALHA 77278) is an LL type ordinary chondrite with petrologic type of 3.7 (LL3.7). Initial observations reported that ALHA 77278 contains 0.3-1.8 mm diameter spherical to ellipsoidal chondrules with nickel-iron and troilite and relatively less matrix [1]. Olivine appears to be Fa_{24}, and pyroxene is low-calcium in composition. In addition, the dark matrix was suspected to include carbonaceous material [1]. ALHA 77278 is reportedly a post-metamorphic breccia containing material with diverse thermal metamorphic histories [2]. Based on the Mossbauer spectra, compositions of chondrules in the ALHA 77278 were found to vary substantially even within very small distances [3]. While iron was found to be present in olivine and pyroxene in some chondrules, it was found only in olivine in another chondrule, and only in pyroxene in other chondrules [3], indicating heterogeneous chondrule compositions. Isotopically heavy nitrogen was also detected in ALHA 77278 but it was found that its abundance was not proportional to that of the solar Ne, indicating complex secondary processes on the surface of its parent body [4]. Some olivines in ALHA 77278 were found to retain a wide range of chemical zoning, indicating that the thermal metamorphism did not result in equilibration [5]. The peak metamorphic temperature for the parent asteroid of ALHA 77278 was reported to be less than 400 °C [5]. There exists very little work on this carbon-rich ordinary chondrite, and, to our knowledge, no vibrational spectroscopic work exists. This work reports micro-Raman spectra, two dimensional chemical distribution maps, carbon spectral parameters and their comparison with other meteorites, effective peak metamorphic temperature of the parent asteroid, and three dimensional tomographic distribution results of ALHA 77278.

Sample and Methods: A thin section of the ALHA 77278 meteorite was received from the Antarctic meteorite collection of NASA Johnson Space Center. The terrestrial weathering grade of the ALHA 77278 is A, suggesting minimal terrestrial contamination. Raman microspectroscopy experiments were conducted at the Vibrational Spectroscopy Laboratory at Stony Brook University using a WiTec alpha300R confocal Raman imaging system, which is equipped with a 532 nm Nd:YAG laser and a 50X objective (NA = 0.8). The laser power on the sample surface was kept below ~1.5 mW. After locating a region of interest in the field of view of the microscope, two dimensional Raman datacubes were collected from an area of 100 μm x 100 μm with 1 μm spatial resolution, and a full Raman spectrum between 100 – 3700 cm^{-1} was collected at every pixel with 0.06 s integration time.

Results: Raman intensity distribution maps show that the studied region consists of olivine, pyroxene, carbon, and magnesiochromite. ALHA 77278 also contains carbon in the matrix, evident from the first order D and G carbon bands. Olivine is the major chemical component in ALHA 77278 and it appears as a doublet in the Raman spectra with peaks at 822 and 852 cm^{-1}. Based on the peak positions of olivine in ALHA 77278 and the calibration by [6], the forsterite content of olivine is near the higher end of the scale, ~Fo_{85}, which indicates that olivine in ALHA 77278, is even more forsteric than was reported in the initial analyses (Fo_{85} vs. Fo_{76}). Several nanodiamond grains were also observed in the Raman data of ALHA 77278, which may be contamination captured during the sample preparation. Based on the Γ_D and peak intensity ratios, ALHA 77278 falls close to unequilibrated ordinary chondrites (UOCs) and CO chondrites. On the other hand, ALHA 77278 falls in between CO3 and CV3 chondrites where, according to the observed trends, the parent asteroid of ALHA 77278 underwent thermal metamorphism to a moderate degree. Based on the thermometry by [7], the effective peak metamorphic temperature of the parent body of ALHA 77278 is calculated to be ~260 °C. Based on the Raman spectra of carbon extracted from the Raman maps, ALHA 77278 is similar to lower petrographic grade meteorites (3.0 – 3.3), despite its official assignment of 3.7.

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