Mineralogical, isotopic, and structural changes of organic materials in experimentally heated Murchison

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Introduction: More than 20 thermally metamorphosed carbonaceous chondrites (TMCCs) have been identified based on the mineralogy, petrology, and organic materials [e.g., 1]. On the other hand, reflectance spectra of C type asteroids suggest that some of them have dehydrated surface [2]. Therefore, the asteroids which experienced dehydration caused by heating after aqueous alteration can be the parent bodies of TMCCs. 1999JU3, a target asteroid of Hayabusa 2 mission that will launch this winter, also shows the evidence of dehydration of the surface [3]. To understand thermal evolution of the C type asteroids, we did heating experiments of Murchison CM chondrite at 600˚C and 900˚C for 1 and 96 hours under controlled oxygen partial pressures. We compare the heating products to four TMCCs, EET 87522, DOM 03183, Belgica 7904 (B-7904), and PCA 02012, based on the mineralogy, oxygen isotopic composition, and structure of organic materials.

Results and discussion: Based on Synchrotron X-ray diffraction analysis for the constituent minerals in the matrices of TMCCs and heating products, the conditions of thermal metamorphism experienced by these meteorites may have been quite variable. The estimated degree of heating is as follow. EET 87522 < DM 03183 < B-7904 = PCA02012. Oxygen isotopic compositions of EET 87522 and DOM 03183 are consistent with that of typical CM2. The oxygen isotope compositions of the experimental products become more ^{18}O rich with increasing temperature. It is consistent with previous studies [e.g., 4]. The prodcut heated at 900˚C well reproduces the oxygen isotope of strongly heated PCA 02012. The samples heated at 900 ˚C for 1 and 96 hours show very similar values. It suggests that the isotopic change would be mass fractionation caused by dehydration of hydrous minerals. It is consistent with the mineraological observation that the dehydration has been completed at 900 ˚C hor 1 hour. However, B-7904 having much heavier oxygen isotopic composition can not be reproduced. It suggests that the original oxygen isotopic composition of B-7904 before thermal metamorphism might be different from that of typical CM chondrites. In addition, maturation grades of carbonaceous materials in the matrices were obtained by micro-Raman spectroscopy. Compare heating products to TMCCs, maturity of organics seems to be strongly dependent on heating temperature than the duration. The degree of heating and the heating temperature estimated from the maturity is following. EET 87522 (less than 600 ˚C) < DOM 03183 (from 600 ˚C to 900 ˚C) < B-7904 (900˚C) < PCA 02012 (over 900˚C).

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