Polycyclic aromatic hydrocarbons and aliphatic hydrocarbons in Jbilet Winselwan carbonaceous CM chondrite, a possible analog of asteroid Ryugu's surface.

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Introduction: On June 27, 2018, Hayabusa2 spacecraft arrived at the C-type asteroid Ryugu [1]. The surface of Ryugu is thought to have experienced thermal metamorphism, according to the remote sensing observations [2, 3]. Therefore, it is important to investigate the chemical compositions of thermally metamorphosed CM chondrites for understanding the surface process of asteroid Ryugu. Although the extents of thermal metamorphism of CM chondrites have been evaluated by mineralogical compositions [4] and elemental and molecular compositions of insoluble organic matter (IOM) [5, 6], the estimated temperature varies widely. On the other hand, soluble organic molecules from the thermally metamorphosed CM chondrites have not been quantified or below detection [7], and there has been no study which evaluated thermal metamorphism based on the compositions of soluble organic molecules. Therefore, in this study, we analyzed polycyclic aromatic hydrocarbons (PAHs) and aliphatic hydrocarbons in Jbilet Winselwan CM chondrite, which is a thermally metamorphosed CM chondrite with highly brecciated and partially shocked lithologies [8] and show similar reflectance spectrum to that of asteroid Ryugu [2], for precise evaluation of parent body thermal metamorphism. The relative abundances of the hydrocarbons were compared with those of Murray CM chondrite.

Samples and Methods: Powdered samples of Jbilet Winselwan meteorite and Murray meteorite (0.2-0.4g) were extracted with dichloromethane/methanol (9:1) by sonication. The extracts were applied to a silica gel column. From the column, aliphatic hydrocarbons were eluated with hexane and then PAHs were eluated with dichloromethane. The hexane and dichloromethane eluates were concentrated to 100 μl individually under a nitrogen flow for analysis by a gas chromatography coupled with mass spectrometry (GC-MS). Identification and quantification of compounds were made by comparison of peak retention times on mass chromatograms and mass spectra, and peak areas, respectively, with those of standard compounds. For compounds without standard compounds, identification was made by comparison of mass spectra with library data.

Results and discussion: Total concentration of PAHs from Jbilet Winselwan meteorite (0.05 μg/g meteorite) was 1000 times lower than those from Murray meteorite (62.0 μg/g meteorite). Di- and trimethylnaphthalenes, fluorene, phenanthrene (PHE), pyrene (PYR), fluoranthene (FLR), methylbiphenyl (0.003-0.039 μg/g meteorite) were identified from Jbilet Winselwan, while low molecular weight PAHs, such as naphthalene, methylnaphthalene, and acenaphthene, were not detected. PAHs with high volatility in Jbilet Winselwan meteorite were probably lost or involved in further aromatization during thermal metamorphism. On the other hand, the ratios of dimethylnaphthalene (DMN) isomers ([2.6-DMN + 2.7-DMN]/1,5-DMN) and FLR to PYR were similar between Jbilet Winselwan and Murray meteorites, indicating that Jbilet Winselwan meteorite experienced a mild degree of thermal metamorphism. According to the shock experiments of PAHs, relative amounts of PHE, FLR, and PYR are significantly reduced to one hundredth under the pressure of 25 GPa [9], while the ratio of FLR to PYR is not changed by impact [10]. The molecular and isomer compositions of PAHs in Jbilet Winselwan meteorite may have resulted by impact pressure higher than 25 GPa.

Total concentration of *n*-alkanes from Jbilet Winselwan meteorite (1.97 μg/g meteorite) was 40 times lower than those from Murray meteorite (80.7 μg/g meteorite). Relative abundances of short-chain *n*-alkanes (C_{14} - C_{18}) were dominant in Jbilet Winselwan meteorite, while those of long-chain *n*-alkanes (C_{19} – C_{24}) were dominant in Murray meteorite. Assuming that these *n*-alkanes are indigenous in the meteorites, this difference implies that short-chain *n*-alkanes were resulted from cracking of long-chain *n*-alkanes and/or IOM during thermal metamorphism of the parent body of Jbilet Winselwan meteorite. Alternatively, the different distributions of *n*-alkanes may be reflected by different sources, as whether the meteoritic *n*-alkanes are indigenous or terrestrial contamination is still under debate.

In this study, we were able to quantify very small abundances of hydrocarbons in a thermally metamorphosed CM chondrite by GCMS, and thus it is expected that soluble organic molecules are detectable from the surface materials of asteroid Ryugu by higher resolution MS, even if they are heated. In order to apply the organic chemistry of Jbilet Winselwan meteorite to understanding of the parent body condition of Ryugu, further investigation of other aliphatic hydrocarbons (that are likely indigenous) and soluble organic molecules, and insoluble organic solids from this meteorite will be necessary.

References: [1] Watanabe S. et al. (2019) *Science* 364: 268-272. [2] Sugita S. et al. (2019) *Science* 364: eaaw0422. [3] Kitazato K. et al. (2019) *Science* 364: 272-275. [4] Nakamura T. (2006) *EPSL* 242: 26-38. [5] Naraoka H. et al. (2004) *MAPS* 39: 401–406. [6] Yabuta H. et al. (2005) *MAPS* 40: 779–787. [7] Shimoyama A. et al. (1989) *Geochemical J.* 23:181-193. [8] Zolensky M. et al. (2016) 47th *LPSC* abstract #2148. [9] Mimura K. and Toyama S. (2004) *GCA* 69: 201-209. [10] Mimura et al. (1994) *Geophys. Res. Lett* . 21: 2071-2074.