

Interactions between minerals and organic materials on thermal processes in meteorite parent bodies

*Naoki Hirakawa¹, Yoko Kebukawa¹, Kensei Kobayashi¹

1. Yokohama National University

Introduction:

Carbonaceous chondrites and several other chondrites contain a few wt.% of organic matters. Pearson et al. (2002) reported co-existence of organic matters with phyllosilicates in the matrix or chondrule rim and discussed the roles of phyllosilicates on alteration of organic matters during aqueous processing in a meteorite parent body. However, interaction between minerals and organics has not been well-known compared to interactions between minerals and water or organics and water. In this study, molecular cloud organic material analogue (Kouchi et al, 2002; hereafter called MC) was heated with powdered minerals using an autoclave to understand, 1) the effect of minerals on thermal metamorphism of organic matter, 2) whether minerals were affected by organic matter or not.

Methods:

MC was prepared by mixing chemical compounds based on Kouchi et al. (2002). Samples used in this study were MC (5 g), MC (0.25 g) with olivine (0.25 g), and MC (0.25 g) + montmorillonite (0.25 g). Each sample was put in a pyrex glass tube without sealing and the tube was placed in the autoclave. The autoclave was purged with N₂+H₂ gas mixture (99 : 1, v/v). The samples were heated at 200 °C, 300 °C, and 400 °C in the autoclave for 5 hours under 1 atm. After cooling to room temperature, recovered samples were analyzed using FT-IR, GC/MS, XRD and SEM-EDS.

Results and Discussion:

MC heated products: Changes of the peak position and the intensity of carbonyl C=O in IR spectra with temperatures were consistent with the products at each temperature detected by GC/MS. The long-chain carboxylic acids in the initial MC were converted into long-chain ester compounds at 200 °C. Long-chain ester, amide and nitrile compounds were produced at 300 °C, and long-chain alkane and nitrile compounds were produced at 400 °C. Dehydration condensation of carboxylic acids with alcohols and amines in the initial MC formed esters and amides, respectively, at 200 °C and 300 °C. Alkanes and nitriles were formed at 400 °C through thermal cracking of long chain aliphatic compounds and dehydration of amides, respectively.

Monoaromatic hydrocarbons also increased at 400 °C. Monoaromatic hydrocarbons were probably formed through thermal cracking of bridged aromatic hydrocarbons (e.g., 4,4'-methylenebis-(2,6-dimethylphenol)) in the initial MC at 400 °C.

Effects of minerals: Changes in the peak position of carbonyl C=O was more significant with montmorillonite than with olivine. Carbonyl C=O significantly decreased at 300 °C and 400 °C with montmorillonite. This result could be explained by the differences of acidity and contact surface area of olivine and montmorillonite.

Alexander et al. (2007) reported that both O/C ratios and H/C ratios of insoluble organic matter (IOM) in heated CM chondrites and ordinary chondrites decreased by heating. However, O/C ratios of IOM in heated CM chondrites were much lower than these in ordinary chondrites when compared at the same

H/C ranges. It may indicate that pyrolysis of IOM in heated CM chondrites was promoted by co-existed phyllosilicates even at lower degree of thermal processes compared to IOM in ordinary chondrites which contain large amount of olivine but less phyllosilicates.

Alteration of minerals: Possibility of partial hydrous alteration in olivine to serpentine was found in products at 200 °C and 300 °C by SEM observations, while the alteration was not detected at 400 °C. It could be due to the dehydration of MC that hydrates olivine at 200 °C and 300 °C. This result might indicate that hydrated minerals could have formed without water but with organics in some meteorite parent bodies accreted inside the snow line. Further analysis using TEM is now being conducted to confirm the formation of phyllosilicates on the surface of olivine particles reacted with MC.

Keywords: pyrolysis of organic matter, meteorite parent body, phyllosilicate