

Effect of thermally decomposed silicate on carbon chemistry in impact-induced vapor clouds

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It is important to know the composition of the gas produced by reaction in impact-induced vapor clouds on the surface of early planets. Resulting gas may play an important role in both the surface environment of the planets and the origin of life. Silicates in the impacting body might affect the composition of the gas produced in the cloud. The experimental study by Mukhin et al. (1989), who used laser-pulse heating on rock and chondrite samples to simulate impact vapor clouds, show that the gas products were composed mainly of the oxidized species (CO, CO₂, etc.) with small amounts of reduced species (hydrocarbons, HCN, CH₃CHO, etc.). This suggests qualitatively that the increase in oxygen fugacity in the cloud by thermal decomposition of silicates leads the production of oxidized species, although the ratio of (CO+CO₂) to hydrocarbons did not increase significantly when the mixing ratio of silicate to carbonous compounds in the samples increased. It is difficult to draw quantitative information on the reaction mechanism of silicates and carbonous compounds in impact vapor clouds only from their experiment. Because the relation between the oxygen derived from thermal decomposition of silicates and gas-phase carbon compounds has not been investigated systematically, the reaction mechanism is still unknown. Then, we attempt to purpose of this study is to investigate the reaction mechanism in this study.

We applied laser pulses on the samples with SiO₂, which is the main constituent of silicates, and coal, which is a substitute for carbonous compounds in planetesimals, with changing their mixing ratio. We then measured the composition of the produced gas as a function of sample mixing ratio. The samples were exposed to Nd: YAG laser pulses (duration 15ns, and frequency 0.5Hz, energy 390mJ/pulse). The ambient pressure around the resulting laser plumes was fixed at 2.0-3.0*10⁻⁴ mbar. We measured the relative production ratios of CH₄, CO, and CO₂ with a quadrupole mass spectrometer (QMS). The result of our preliminary experiments shows that CH₄/(CO+CO₂) increases proportional to the mixing ratio of coal raised to a power about 0.6. This means that a smaller ratio of coal (and larger ratio of SiO₂) in the sample leads to a larger ratio of oxidized species in the produced gas.

Our result qualitatively supports the conclusion by Mukhin et al. (1989) that the oxygen derived from thermal decomposition of silicates leads to oxidized carbonaceous species. This reconfirms that the effect of thermal decomposition of silicates needs to be taken into account when carbon chemistry in impact-induced vapor cloud is considered.

There is, however, quantitative difference between our result and the result by Mukhin et al. (1989). Our CH₄/(CO+CO₂) data follow a power-law relation, while their data have no significant trend. Furthermore, their CH₄/(CO+CO₂) data are far above the extrapolated line of our data. The ratio of CH₄, which is a reduced species, to CO and CO₂, which are oxidized species, in the vapor cloud is one of the most important factors when we consider a planetary surface environment and the origin of life. A reduced atmosphere is favorable to the origin of life. The difference between our result and the result by Mukhin et al. (1989) has to be investigated in detail.

There are several possible causes for the difference, such as quench temperature, power of the laser, and samples employed. In particular, the effect of change in quench temperature of the reaction due to the difference in ambient pressure is important. We are conducting experiments to understand the effect of the ambient pressure. We will present the results of the ongoing laser experiments on the pressure effect as well in the conference.

Reference: Mukhin, L. M., Gerasimov, M. V., and Safonova, E. N., *Nature*, 340, 46-48, 1989.