Birth-place of comet 17P/Holmes from its mass fractions of minerals

*Shinnaka Yoshiharu[1], Takafumi Ootsubo[2], Hideyo Kawakita[1], Mitsuru Yamaguchi[1], Mitsuhiko Honda[3], Jun-ichi Watanabe[4]

1. Kyoto Sangyo University, 2. JAXA/ISAS, 3. Kurume University, 4. NAOJ

Comets are considered as the most pristine icy small objects in the solar system. They are likely to have kept the information about the solar system formation. Physical properties of cometary dust grains and composition of cometary volatiles are precious clues to physico-chemical conditions of the solar nebula. Comet 17P/Holmes is a Jupiter-family comet with an orbital period of ~7 yrs. Comet Holmes exhibited a great outburst starting on UT 2007 October 23 when the comet was 2.5 au from the Sun and five months after the perihelion passage. Because the observed relative abundance ratios of volatiles with respect to water in comet Holmes are enriched compared with other comets (Dello Russo et al. 2016, Icarus, 278, 301), it is thought that the nucleus of comet Holmes formed at a further distance from the Sun in the solar nebula (SN).

Silicate grains in the interstellar space are considered almost in amorphous form (only a few percent of mass or less is considered as crystalline for silicate; Kemper et al. 2004, ApJ, 609, 826). However, abundant crystalline silicate grains have often been found in cometary grains (up to ~80% by mass with large variety among comets; Hanner et al. 1994, ApJ, 425, 274; Wooden et al. 1999, ApJ, 517, 1034; Ootsubo et al. 2007, P&SS, 55, 1044, and references therein). It is thought that these crystalline silicates in comets formed by annealing of interstellar amorphous silicate grains or by direct condensation of gaseous materials in a hot region of the SN, and incorporated into cometary nuclei after they were transported to the cold comet-forming region (several to 30 au from the Sun). In this scenario, it is expected that mass fraction of the crystalline silicates in cometary dust grains tends to be smaller at further distances from the Sun.

We discuss the possibility that comet Holmes formed in a colder region in the SN rather than other comets based on the mass fraction of crystalline silicates in silicate grains. We derived mineral abundances in comet Holmes by applying the thermal emission model for cometary dust grains (Ootsubo et al. 2007, P&SS, 55, 1044; Shinnaka et al. 2018. AJ, 156, 242) to the mid-infrared spectra of comet Holmes taken with the COMICS on the Subaru Telescope from UT 2007 October 25 to 28. The derived mass fraction ratios of crystalline silicate of comet Holmes (~30%) is the almost smallest among comets studied in previous articles, supporting the hypothesis that comet Holmes formed at a further distance from the Sun in the SN compared with other comets. At such a cold region, hyper volatile ices like CO and amorphous water ices (possible energy sources for explosive sublimation) would be abundant.
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