methane and water reaction in the Earth's mantle

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Physical properties of mantle minerals and partial melting are considerably depends on C-O-H fluids. It is important to understand existence and states of fluids in the mantle. Oxygen fugacity of the curst and the upper part of mantle is so high that CO_2-H_2O fluid is stable. While, that of the lower part of mantle is low enough for CH_4- H_2Ofulid to be stable. Existence of Methane was found in diamond inclusions and hydrocarbons were found in mantle xenoliths. High-pressure high-temperature experiments and theoretical calculations showed formation and stability of methane and hydrocarbons in the Earth's upper mantle condition. Here we show effect of methane-water fluid on olivine stability, stability of methane, and formation of heavier hydrocarbons under mantle condition.

High-pressure and high-temperature experiments of olivine -methane- water system, olivine-methane system, and olivine-water system were performed at pressures at (1)5.5-6.45GPa,1200-2200K (2)9.15-9.83GPa,-1800K (3)14.5-19.5GPa,-2000K (4)29.4GPa,-2000K. Diamond anvil cell (DAC) combined with Nd-YAG laser or CO_2 laser heating system were used.

After cooling, X-ray diffractometry and Raman spectroscopy were performed. XRD patterns showed that existence of olivine, solid methane and their high pressure phases were observed. In addition, new diffraction lines were observed at 5.4GPa and 29.4GPa samples. Raman study indicated that the intensity of C-H vibration mode of methane molecule decreased in the heated areas. And, a few vibration modes were observed in C-C vibration region. Some of them were assigned to that of ethane molecule. Raman spectra of the recovered samples from the high pressure experiments showed vibrations mode of 1450cm-1 and 2900cm^{-1} to 3000 cm^{-1} peaks assigned as C-H vibration mode of hydrocarbons. Around 1350cm^{-1} and 1590cm^{-1}, new peaks were also observed that assigned as D-band and G-band of graphite and/or glassy carbon. Some olivine particles showed Si-O vibration lower than that of the starting material.

The present results suggest that methane molecules partly dissociate and dissociate completely into carbon atoms and hydrogen in the Earth's mantle.