Water and methane reaction in the earth's mantle

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Physical and chemical propertys of mantle minerals are considerably depend on fluids such as water and Carbon dioxide. It is important to understand existence and stability of fluids in mantle. There were various experiments about water in the Earth's mantle. It has been showed that minerals in transition zone and subducting slab are able to contain a large amount of H_2O. Carbon exist in the mantle as carbonate, carbon dioxide, diamond and graphite. Interior of the earth is high-oxidation state and high-temperature. So, it was thought that methane and hydrocarbons are limited because these materials are stable under reducing conditions. However, methane was found in diamond inclusions and hydrocarbons were found in mantle xenoliths. Furthermore, formation and stability of methane and hydrocarbons in the Earths upper mantle condition was reported by high-pressure high-temperature experiments and theoretical calculations. Here we show three hypotheses. Effect of methane-water fluid on olivine stability. Stability of methane. Formation of heavier hydrocarbons under mantle condition.

High-pressure and high-temperature experiments of olivine ($Fe_{0.1}.Mg_{0.9})_2SiO_4$)-methane-water system were performed at pressures at 5.4GPa, 5.6-6.3GPa, 14.8GPa, 19.8GPa and 29.4GPa, and at temperatures 1200-1300K and above1500K. A high-pressure and high-temperature experiment of olivine- water system was also performed at 19.5GPa and above 1500K. Diamond anvil cell (DAC) combined with a Nd-YAG laser heating system was used.

Heating area changed to black, which was not observed the in olivine-water system. After cooling, X-ray diffractometry and Raman spectroscopy were performed. XRD patterns revealed that olivine transformed to high pressure phases, wadslyite and ringwoodite at 14.8GPa and 19.5GPa. Under the condition of 29.4GPa and above 1500K, perovskite was formed in dark area but magnesiowustite was not detected. Besides the diffraction lines of olivine, wadslyite, ringwoodite and perovskite, new diffraction lines were observed at 5.4GPa, 5.6-6.3GPa and 29.4GPa samples. Raman study indicated that C-H vibration mode of methane decreased in dark heated areas. In addition, new C-C vibration modes were observed. Some of them were assigned to C-C vibration mode of ethane. Raman spectra of the recovered samples from the high pressure experiments showed many vibrations mode of 1600cm^{-1} and 2900 to 3000 cm^{-1}.These peaks were assigned as C=C vibration and C-H vibration mode. These results indicate that various hydrocarbon phases which were stable solid phase in ambient condition were produced. TEM analese also indicated that some hydrocarbon phase were observed contact with the silicate minerals.

The present results suggest that heavier hydrocarbons are formed from methane and they are stable under the mantle conditions.