Polymerization of methane molecules and release of hydrogen under the Earth's mantle conditions

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Existence and states of C-O-H fluids in the Earth's mantle are important issues to be understood, because they relate considerably to the mantle dynamics. In general, the speciation of C-O-H fluids was controlled by the oxidation state of the mantle. CO_2-H_2O fluids are stable in the curst and the upper part of the mantle where oxygen fugacity is high. CH_4 H_2O fluids are stable in the lower part of the mantle where oxygen fugacity is low. In fact, methane was found in diamond inclusions. Many studies on the states of water in the mantle minerals were previously performed. However, study on effects of methane fluid on mantle minerals was extremely limited. In this study, high-pressure and high-temperature experiments of methane fluid-olivine system were performed under the mantle conditions. Stability of methane, formation of heavier hydrocarbons was examined. In addition, the effect of methane on phase transition of olivine to high pressure phase and the crystal structure were examined.

The X-ray diffractometry and Raman spectroscopy showed ethane molecules and heavier hydrocarbons besides methane molecules. Graphite and glassy carbon were also founded. Polymerization of the methane molecules occurred even under the conditions where olivine coexists, although most of methane remained unchanged. And, observation of graphite and glassy carbon indicate that the polymerized methane molecules changed to finally to carbon and hydrogen. Polymerization of methane molecules resulted in release of hydrogen. Effect of the released hydrogen on olivine structure was examined.