The 460th Geodynamics Seminar

Experimental study on the stability and physicochemical behavior of methane hydrate under high pressure and high temperature

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Date: 16 Dec. (Fri.) 2016, 16:30 ~
Venue: Meeting Room #486, Science Research Bldg. 1, Ehime Univ.

日時：2016年12月16日(金)16:30～
場所：愛媛大学 総合研究棟Ｉ 4階共通会議室

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Abstract

Methane hydrate (MH) is thought to be an important constituent of icy planets and their satellites, such as Neptune, Uranus and Titan. On Earth, MH is found in significant quantities in oceanic deposits, in permafrost as well as in polar ice sheets. It is a clathrate compound composed of hydrogen-bonded water cages (host) and molecules or atoms (guests) included in the cages. MH has an sI cage structure at low (< 0.8 GPa) pressures and room temperature. It transforms to an sH cage structure at approximately 0.8 GPa, which further transforms to a filled-ice Ih structure at approximately 1.8 GPa. The Ih structure consists of an ice framework similar to ice Ih and voids that are filled with methane molecules (e.g. Loveday et al. 2001; Shimizu et al. 2002). This structure was found to be stable up to at least 86 GPa, supporting that MH might be stable in the deep interior of icy bodies. Although the sequence of the phase transitions with pressure have been studied well at room temperature, there are only a few studies that addressed the stability of MH under high pressure and high temperature (e.g. Kurnosov et al. 2006; Bezacier et al. 2014). In addition, the pressure range of these previous studies is only limited to < 5 GPa. Therefore, a further investigation is needed to understand the stability and physicochemical behavior of MH under extreme conditions corresponding to the interior of icy bodies.

In this study, we carefully investigated the stability and decomposition mechanism of MH in an externally-heated diamond anvil cell in the range of 2-51 GPa and 298-653 K using in-situ Raman spectroscopy and X-ray diffraction. These results show that MH decomposes to ice VII and solid methane at temperatures considerably lower than the melting curves of solid methane and ice VII in the pressure range of 2-51 GPa. The decomposition conditions of MH that were obtained at high pressure have important consequences for the storage and transport of methane in the deep interior of icy bodies. These data are useful not only for investigation the internal structure of icy bodies but also for understanding the physicochemical properties of gas hydrate.

詳細は当センターホームページ: http://www.grc.ehime-u.ac.jp/をご覧ください
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