Decomposition behavior of brucite at high pressure and temperature -variation of MgO solubility in aqueous fluid with pressure-

Taku Okada[1], Wataru Utsumi[2], Masaaki Yamakata[3], Nozomu Hamaya[4], Osamu Shimomura[1]

[1] SPring-8/JAERI, [2] JAERI, [3] SPring-8, [4] Grad. School Humanities. Sci., Ochanomizu Univ.

1. Introduction

Recently, it has been revealed experimentally that H_2O can dissolve Earth's mantle materials (e. g., Nakamura and Kushiro (1974) Carnegie Inst, Mibe et al. (1997) Terra Nova, Fujii et al. (1997) Kagaku, Shen and Keppler (1995) Nature, Kawamoto et al. (2001) this meeting).   However, it was reported that brucite ($Mg(OH)_2$) underwent a dehydration reaction to produce periclase (MgO) and pure H_2O even at high-pressure regions (e. g., Johnson and Walker (1993) Am Mineral).   In this study, we attempt to observe directly the decomposition behavior of brucite at high pressure and temperature by means of in situ X-ray diffraction method.

2. Experimental

Experiments were carried out using an 180 ton cubic-anvil press installed on the BL14B1 beamline at the SPring-8.   We used six tungsten carbide anvils with 4-mm edges for pressure generation, a mixture of boron and epoxy resin as the pressure medium and cylindrical graphite as the furnace in conjunction with molybdenum electrode.   We utilized a double insertion where the graphite capsule was further inserted into another capsule made of molybdenum foil.   In order to avoid grain growth of the coexisting solid phase with fluid and the phase separation by the temperature gradient, we used fine powder mixture of brucite and graphite as the starting material.   As the solubility of carbon in H_2O is very small (much less than % order) (Liu et al. (2001) AIRAPT), the effect of carbon presence to the phase relation is expected to be very small.   In situ X-ray observations were performed by energy dispersive powder diffraction using white X-rays and SSD.   Pressures were calculated from the lattice constants of NaCl using the Decker scale.   The temperature was monitored by a W/Re thermocouple.   Pressure was first increased at room temperature, and then the temperature was increased at a constant applied load.   Before or after the decomposition temperature of brucite, X-ray diffraction profiles of the sample were collected at various high pressures.

3. Results and discussion

In the experiment at around 3.6 GPa, upon increasing the temperature from 900 degree C to 1050 degree C, the diffraction peaks of brucite disappeared while the diffraction peaks of periclase appeared, corresponding to the dehydration decomposition reaction reported by previous quench experiments.   Supercritical aqueous fluid was expected to coexist with periclase under these conditions.   When the temperature was decreased to 900 degree C, brucite peaks reappeared.   In this reaction, the periclase peaks survived and their intensity did not change significantly, strongly suggesting that the reproduction of brucite was caused not by a rehydration reaction between pure H_2O and periclase, but mainly by crystallization from the aqueous fluid that had already dissolved the MgO component.

In the experiment at around 6.2 GPa, the diffraction peaks of brucite disappeared when the temperature was increased from 1050 degree C to 1150 degree C.   In contrast to the result at 3.6 GPa, no diffraction peaks of periclase were observed.   This observation suggests that complete melting of brucite occurred without crystallizing periclase.   When the temperature was decreased to 1050 degree C, the diffraction peaks of brucite reappeared, however, periclase peaks were not observed.   In the experiment at around 8.3 GPa, brucite peaks disappeared as the temperature increased from 1100 degree C to 1200 degree C without the appearance of periclase peaks.

According to the present experimental results, it is natural to conclude that the solubility of the MgO component in the aqueous fluid increases with increasing pressure and reaches greater than 50 mol % at 6.2 GPa.   This conclusion is consistent with the experimental results by Mibe et al. (1997) and Fujii et al. (1997).   The present results suggest a triple point (brucite, periclase + fluid, fluid) in the phase diagram of $Mg(OH)_2$ at around 5 GPa.