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The compressibility of natural norbergite, $Mg_{2.98}Fe_{0.01}Ti_{0.01}Si_{0.99}O_4(OH_{0.31}, F_{1.69})$

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Introduction

Norbergite (n=1), which is a hydrous magnesium silicate mineral, is known as one of the humite minerals described as $n Mg_2SiO_4 \cdot Mg(OH,F)_2$ (n=1-4). Also, forsterite, Mg_2SiO_4, is known as the most important mineral in the Earth's mantle. Forsterite and the humite minerals constitute the polysomatic series. The humite minerals are important in the view of the carriers and reservoirs of water in the Earth's deep interior, because these minerals are stable under high-pressure and high-temperature mantle conditions [1].

We performed a high-pressure single crystal X-ray diffraction study on a natural norbergite at ambient, 0.5, 3.1, 4.2, 4.7, 5.4, 6.3, 7.6 and 8.2 GPa in order to investigate its compressibility and crystal structure. In this paper, we reported the axial linear compressibility and the isothermal bulk modulus of this specimen.

Experimental Procedure

The sample used for this study is from Sterling Hill Mine, New Jersey, U.S.A. A single crystal of norbergite ($60\times50\times40$ μm^3 in size) was mounted in a modified Merrille-Bassett type diamond anvil cell with a small piece of a ruby crystal, which used for the pressure calibration. The 4:1 fluid mixture of methanol and ethanol was used for the pressure medium and a SUS301 stainless plate used for a gasket. Pressure was determined by the ruby fluorescence method [2]. The wavelength of synchrotron radiation was calibrated by the unit cell volume of the ruby standard crystal at ambient temperature (λ=0.7004 Å for 0.5, 3.1, 4.2 and 5.4 GPa; λ=0.7002 Å for 4.7 and 6.3 GPa; (λ=0.6989 Å for 0.0001, 7.6 and 8.2 GPa). The X-ray diffraction were measured using an automated four-circle X-ray diffractometer installed at the beam line BL-10A, Photon Factory, High Energy Accelerator Research Organization. The unit cell parameters of norbergite were determined from 25 centered reflections in the 2θ range between 12.5° and 30.9° under all high-pressure conditions.

Results

The unit cell parameters of norbergite at each pressure condition were listed in Table 1. The axial linear compressibilities of this norbergite were calculated using these results, yielding to β_a=2.18(4), β_b=2.93(7) and β_c=2.77(7) ($\times 10^{-3}$ / GPa). The big and small relationship of linear compressibility of norbergite was the same as those of the other humite minerals.

In similarly, the isothermal bulk modulus of this specimen was calculated as K=113(2) GPa assuming K'=4. This result is plotted on the simple positive correlation [3] between K and density (ρ) of the minerals in some dense hydrous silicate minerals (Fig. 1).

Table 1. The lattice parameters of natural norbergite at each pressure point up to 8.2 GPa

P (GPa)	*a*	*b*	*c*	*V*
0.0001	4.709(2)	10.279(3)	8.754(4)	423.7(2)
0.5	4.701(2)	10.254(2)	8.736(3)	421.1(2)
3.1	4.674(2)	10.176(2)	8.670(3)	412.3(2)
4.2	4.662(2)	10.138(2)	8.642(3)	408.5(2)
4.7	4.657(2)	10.120(3)	8.626(3)	406.5(2)
5.4	4.652(2)	10.114(2)	8.619(3)	405.5(2)
6.3	4.645(2)	10.085(2)	8.604(3)	403.1(2)
7.6	4.637(2)	10.059(2)	8.574(3)	399.9(2)
8.2	4.625(2)	10.049(2)	8.569(4)	398.2(2)

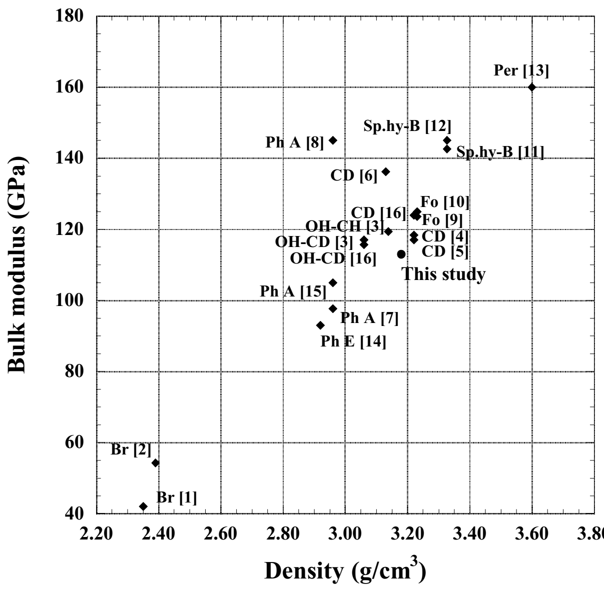

Figure 1. The relationship between density and bulk modulus in some dense hydrous silicate minerals.

References

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