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# Equation of state of Al-bearing Mg-perovskite in a pyrolitic mantle to 80 GPa

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## Introduction

An Al-bearing Mg-perovskite is generally accepted to be the dominant phase of the Earth's lower mantle. Information on its density and bulk and shear modulus under various pressures and temperatures is, therefore, of prime importance in determining the composition and properties of the lower mantle. However, some experimental data indicate that the presence of aluminium in Mg-perovskite causes significant changes in its chemical and physical properties. In this study, I investigated the pressure-volume EOS of Al-bearing Mg-perovskite possessing the pyrolitic (KLB-1 peridotite) composition up to a pressure of 80 GPa, which is equivalent to the pressure of the lower mantle. The orthorhombic perovskite contained some minor components, such as FeO, $Al_2O_3$, $TiO_2$, CaO, and $Na_2O$.

## Experimental methods

Polycrystalline Al-bearing Mg-perovskite was synthesized in a multi-anvil apparatus (SEDI-1000) [4] at the Magma Factory at the Tokyo Institute of Technology, Japan. A synthetic gel was used to produce a reactive and homogeneous starting material [5]. The high-pressure X-ray diffraction experiments were performed using a laser-heated diamond anvil cell (LHDAC) high-pressure apparatus. The synthesized Al-bearing Mg-perovskite was loaded into a hole that had been pre-drilled into a rhenium gasket using an excimer laser. Argon was used as the pressure transmitting medium, and Au foil was placed in the sample chamber for use as an internal pressure calibrant. After each change in pressure, the sample was heated using a multimode YAG laser to reduce the generation of pressure inhomogeneity in the sample. Some reliable studies of equations of state of high-pressure minerals were reported using the similar laser-heated annealing method [6]. The sample was probed using angle-dispersive x-ray diffractometry using the synchrotron beam line BL13A of the PF, KEK [8].

## Results and Discussion

The powder X-ray diffraction data of Al-bearing Mg-perovskite at ambient pressure revealed that this phase had an orthorhombic cell (space group *Pbnm*). The effects of pressure on the unit cell volume of the Al-bearing Mg-perovskite are shown in Figure 1. To determine the elastic parameters, the *P-V* data were fitted to the Birch-Murnaghan equation of state. When $Ko' = 4$ and Anderson's EOS of Au was used [10], the value of bulk modulus, *Ko*, was determined to be 272(8) GPa.

My study showed that the bulk modulus increased slightly compared with that of $MgSiO_3$ perovskite. In previous studies, the bulk modulus of Al-bearing Mg-perovskite was determined at metastable conditions. An extrapolation of the low values determined at metastable conditions to the whole lower mantle is questionable, because Al-bearing Mg-perovskite exists at pressures of between 25 and 135 GPa in the lower mantle. A deterioration in synthetic Al-bearing Mg-perovskite, which may affect its physical properties, was observed by Ito et al. [12] after the release of pressure. Thus, it is important to measure the bulk modulus of Al-bearing Mg-perovskite at pressures observed in the lower mantle.

## References

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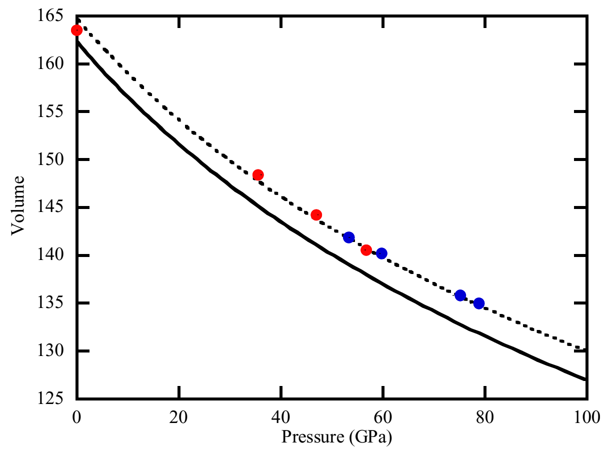


**Figure 1**
Pressure-volume data for orthorhombic Mg-perovskite at 300 K. The powder X-ray diffraction results are shown by the blue circles (compression) and red circles (decompression). Dashed curve: third-order Birch-Murnaghan equation fit, $Ko = 272$ GPa, *Ko'* is fixed to 4, and using Anderson's EOS of Au. The solid line represents the EOS of pure $MgSiO_3$ perovskite [13].