

## Formation of the perovskite solid solution in the system of $\text{MgSiO}_3\text{-MnSiO}_3$ at high pressure and high temperature

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### Introduction

It is accepted that magnesium silicate perovskite ( $\text{MgSiO}_3\text{-pv}$ ) is the major constituent mineral in Earth's lower mantle. Natural minerals commonly form solid solutions and it is known that various cations are possibly incorporated into  $\text{MgSiO}_3\text{-pv}$ . Solubilities of FeO and CaO into  $\text{MgSiO}_3\text{-pv}$  have been mainly investigated so far. The system of  $\text{MgSiO}_3\text{-CaSiO}_3$  has almost no perovskite solid solution in the whole lower mantle conditions. The solubility of FeO is only about 10 mol% at the uppermost lower mantle condition, but it is expected to increase greatly with depth.

Recently a new silicate perovskite with  $\text{MnSiO}_3$  composition was reported [1]. Because the ionic radius of  $\text{Mn}^{2+}$  is between those of  $\text{Fe}^{2+}$  and  $\text{Ca}^{2+}$ , it should be interesting to evaluate the solubility of MnO into  $\text{MgSiO}_3\text{-pv}$  at high pressure.

In this proposal, we performed high pressure and high temperature synthesis for solid solutions in the system of  $\text{MgSiO}_3\text{-CaSiO}_3$  and identified the products phases by X-ray diffraction measurements.

### Experimental

We firstly prepared gels containing desired amount of Mg, Mn and Si by a sol-gel method. Then we heated them at 1023 K for 3 hours under the controlled oxygen fugacity in order to keep  $\text{Mn}^{2+}$ . We finally made starting materials with desired chemical compositions (mol ratios:  $\text{MnSiO}_3 : \text{MgSiO}_3 = 3 : 1, 1 : 1, 3 : 1$  and  $1 : 9$ ).

High pressure was generated by using a symmetry type DAC with 200 or 300  $\mu\text{m}$  culets diamond anvils. Sample was sandwiched between NaCl pellets and loaded into the DAC. NaCl works not only as a pressure transmitting materials but also as a thermal insulator. Small amount of gold powder was added to the sample as internal pressure marker. The diameter of a sample chamber in a pre-indented Re gasket is 80-100  $\mu\text{m}$ . The sample was heated for about 1 hour from both sides with an YLF laser at our laboratory or a YAG laser installed in BL13A or NE1A beam line. Experimental conditions were at the pressure range between 30 – 60 GPa and at the temperature range between 1300 ( $\pm 200$ ) – 2000 ( $\pm 200$ ) K.

X-ray diffraction patterns were measured by an angle dispersive method using an imaging plate (IP). Two dimensional IP data were integrated along Debye-Scherrer rings and converted to one dimensional data by the software IPAnalyzer [2].

### Results and Discussion

X-ray diffraction patterns of all run products at high pressure suggest that a single phase of orthorhombic perovskite can be synthesized in each run product. The unit cell parameters increase almost linearly with  $\text{MnSiO}_3$  contents as shown in Figure 1. This suggests that a complete perovskite solid solution can be formed in the system of  $\text{MgSiO}_3\text{-MnSiO}_3$ . These perovskite phases except for those with  $\text{MgSiO}_3$  and  $(\text{Mg}_{0.9}\text{Mn}_{0.1})\text{SiO}_3$  compositions transform into amorphous phase during decompression to an ambient pressure. It is very exciting report that  $\text{MnSiO}_3$  is the first end member which forms a complete perovskite solid solution with  $\text{MgSiO}_3$ .

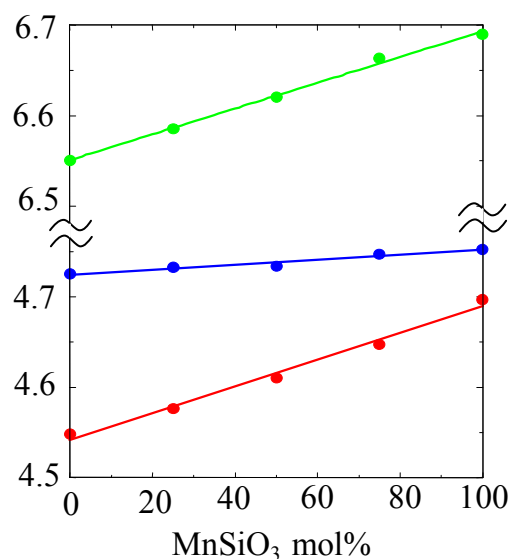


Figure 1. Variations of unit cell parameters of orthorhombic perovskites at about 50 GPa as a function of  $\text{MnSiO}_3$  mol%. Red, blue and green symbols represent dimension of the  $a$ ,  $b$  and  $c$  axis, respectively.

### References

- [1] K. Fujino et al., *Am. Mineralogist*, 93, 653 (2008).
- [2] Y. Seto et al., *Review High Press. Sci. & Tech.*, 20, 269 (2010).

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