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Phase relation in $MgSiO_3$ under mantle conditions

Shigeaki ONO[1],*
[1] Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka 237-0061, Japan

1 Introduction

As olivine, pyroxene and garnet are major minerals in the upper mantle, understanding the dynamics and evolution of the mantle requires knowledge of $MgSiO_3$, which is an end-member of pyroxene. Therefore, phase relations in $MgSiO_3$ have been repeatedly investigated by a number of authors. However, the transition sequence of the $MgSiO_3$ mineral remains as yet unconfirmed. The discrepancy among researchers is likely due to the accuracy of phase boundary determinations related with the stability field of two phases, wadsleyite + stishovite or ringwoodite + stishovite.

2 Experiment

High-pressure experiments were carried out using multi-anvil high-pressure apparatus installed at the synchrotron facilities of KEK and SPring-8 in Japan. Experimental details were described elsewhere [e.g., 1,2]. A mixture of the powdered $MgSiO_3$ and gold was used. Experimental pressures were determined from the unit cell volumes of gold. All recovered samples were investigated by an electron microprobe analyzer to identify the stable phase in each experimental run.

3 Results and Discussion

Experimental runs were performed at pressures between 15 and 21 GPa (Fig. 1). Two types of recovered samples, single ($MgSiO_3$) and two phases (Mg_2SiO_4 + SiO_2), were confirmed. The single phase was high-pressure clinoenstatite or akimotoite, and two phases were wadsleyite + stishovite or ringwoodite + stishovite. According to experimental data, two reaction boundaries were determined. The reaction boundary between high-pressure clinoenstatite and wadsleyite + stishovite has a positive dP/dT gradient, 0.0064 GPa/K [3]. In contrast, the reaction boundary between ringwoodite + stishovite and akimotoite has a negative dP/dT gradient, -0.0012 GPa/K [4]. This study indicates that the stability field of wadsleyite + stishovite expands to a low temperature region corresponding to the P-T path in the subducted slab. Moreover, a triple point of wadsleyite + stishovite-ringwoodite + stishovite-akimotoite is located at a temperature slightly lower than the geotherm (Fig. 2). These experimental results can reconcile the inconsistency recorded between previous studies regarding the phase relation in $MgSiO_3$.

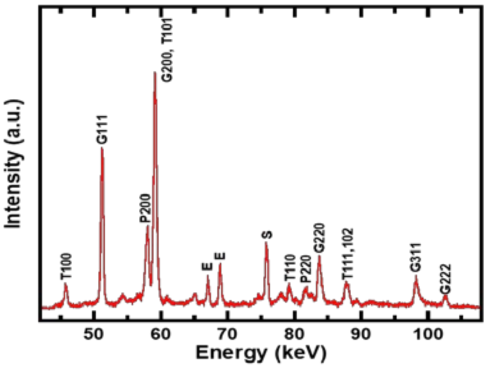

Fig. 1: Example X-ray diffraction pattern acquired at 17.1 GPa and 1200 K. Key to label abbreviations: G, gold (Au); E, emission of gold fluorescence; T, TiB_2; P, periclase (MgO); and S, unidentified spot peak.

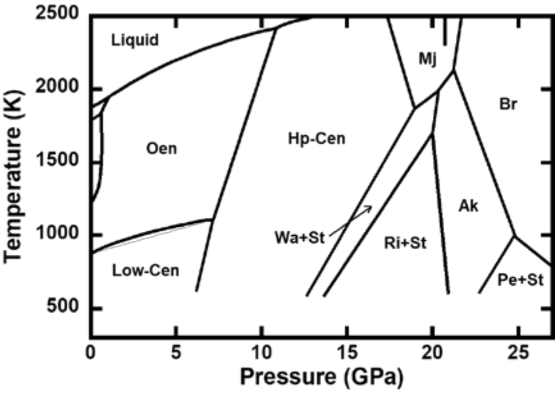

Fig. 2: Phase diagram of $MgSiO_3$ estimated based the present and previous studies. Abbreviations: Low-Cen, low clinoenstatite; Oen, orthoenstatite; Hp-Cen, high-pressure clinoenstatite; Wa, wadsleyite; Ri, ringwoodite; St, stishovite; Mj, majorite; Ak, akimotoite; Br, bridgmanite; Pe, periclase.

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References

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* sono@jamstec.go.jp