Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.21546

Pressure induced structural transition in Deep Terrestrial Magma Ocean

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Terrestrial planets in principle go through multiple episodes of magma ocean (MO) basically mainly due to metal-silicate segregation during core formation (1), and giant impact due to the formation of Moon from planets (2,3). Hence, the clarification of the structure and physical properties of silicate melts (primary component of MO) under extremely high-pressure conditions relevant to deep MOs in the terrestrial planets is very crucial. However, very little is known about the structure and physical properties of silicate melts under corresponding deep MO conditions due to the experimental hurdles (4). Here, we conducted *in-situ* high-pressure acoustic wave velocity measurements of (Fe^{2+}, Al)-bearing $MgSiO_3$ glass analogue to silicate melts up to pressures of 155 GPa.

The acoustic wave velocity measurements were carried out using Brillouin spectroscopic technique combined with diamond anvil cell high-pressure apparatus. The transverse acoustic (TA) wave velocity profile of (Fe, Al)-silicate glass becomes anomalously steeper above 98 GPa and eventually came to be equivalent to that of pure $MgSiO_3$ glass above ~125 GPa (Fig. 1). This steeper TA velocity profiles were observed at 140 GPa in SiO_2 (5) glass and 133 GPa in $MgSiO_3$ glass (6) and claimed to be the change in coordination number of Si-O from 6 to greater than 6 in the prior studies. Our data implies that the incorporation of Al into Fe^{2+}-bearing $MgSiO_3$ glass significantly reduces this transition pressure and facilitates making it far elastically stiffer and thus the possible existence of ultra-stiff and dense isolated gravitationally stable silicate melts layer located at a greater depth than 100 GPa deep in the Si-enriched rocky terrestrial planets.

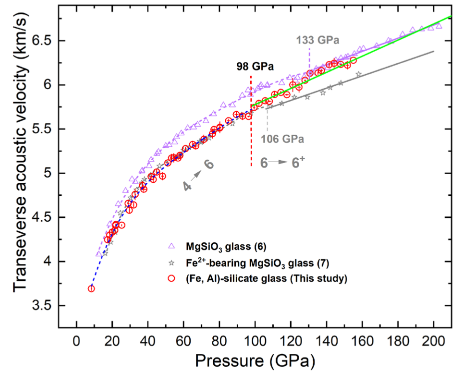

Fig. 1. Transverse acoustic wave velocities of $MgSiO_3$, Fe^{2+}-bearing $MgSiO_3$, and (Fe, Al)-silicate glass.

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