THE GEODYNAMICS SEMINAR

Nº 650

Lower mantle composition inferred from sound velocity measurements on Al,Fe-Bridgmanite

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2025.12.26 (Fri.) 16:30 ~

Venue: Meeting Room #486

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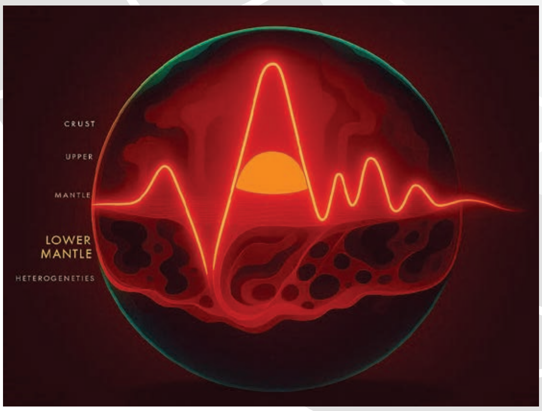
Keywords

1. Lower mantle composition
2. Elastic wave velocity
3. Bridgmanite

The lower mantle constitutes the largest and deepest portion of Earth's mantle, accounting for over 80 vol.% of the bulk silicate Earth. As such, it plays a critical role in geochemical and geodynamical processes of the Earth's interior. The lower mantle is predominantly composed of iron-bearing aluminous bridgmanite (Brg), a magnesium-rich silicate with a perovskite structure. In other words, a precise knowledge of the elasticity of Al,Fe-Brg at the pressure and temperature conditions of the Earth's lower mantle is the most pivotal pieces of information in Earth sciences for interpreting seismic models at depth, which would in turn gives important clues about chemical composition, internal structure and dynamics of our planet's deep interior. Previous studies have demonstrated that bulk adiabatic and shear moduli of Brg decrease by the incorporation of few wt.% FeO or Al_2O_3. The combined effect of Fe and Al on the elasticity of bridgmanite is however still controversial with some study reporting Al,Fe-Brg velocities compatible with a pyrolitic uppermost lower mantle (Kurnosov et al., 2017) while another argued that incorporation of $FeAlO_3$ would favor a Brg-enriched lower mantle (Fu et al., 2023). Thus, on the account of scarce experimental data and absence of in situ measurements at high T, the composition of the lower mantle is still mostly unconstrained.

Here we report simultaneous elastic wave velocity and density in situ measurements on Brg specimen with a pyrolitic composition using ultrasonic interferometry combined with synchrotron X-ray techniques and the multianvil apparatus. Our data showed a substantial V_S/V_P discrepancy between Brg with low and high Al/Fe ratio despite the quasi-identical bulk chemical composition. Based on our new elasticity data, we found that pyrolite velocities matches with those of PREM at depths in between 800 km and 1200 km. In contrast, pyrolite always have velocities lower than those of PREM at depths below 1200 km. Since velocities of other mantle minerals are also lower than PREM, the discrepancy between PREM and pyrolite models cannot be explained by an increase of basaltic components and thus suggest the lower mantle below depths of 1200 km may be primarily constituted of Fe- and Ca-depleted primitive lithologies.



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