
# Japan Association of Mineralogical Sciences

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## DEEP IRON INCORPORATION FROM EARTH'S CORE INTO THE MANTLE VIA IRON–WATER EXCHANGE

At the Earth's core–mantle boundary (CMB), an environment characterized by extreme pressure and temperature, dynamic interactions occur between the liquid metallic core and the overlying mantle minerals. Seismological observations have revealed the presence of chemical heterogeneities in the lowermost mantle, known as the ultra-low velocity zones (ULVZs), where seismic waves propagate exceptionally slowly. To understand the origin of these anomalous regions, many researchers—including teams from Japan—have conducted extensive investigations. Here, we briefly introduce a new hypothesis proposed by Kawano et al. (2024) to explain the origin of ULVZs.

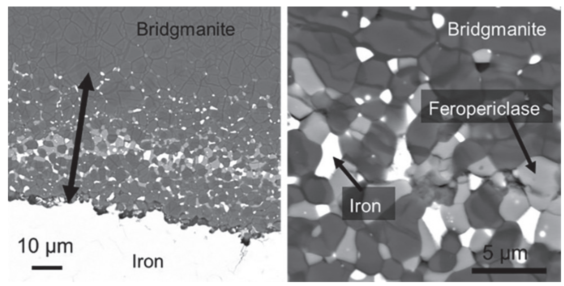


**FIGURE 1** Back-scattered electron (BSE) images showing the formation of an iron-rich layer between bridgmanite and iron under hydrous conditions.

Using a multi-anvil apparatus, researchers simulated the conditions at the core–mantle boundary, where liquid iron interacts with mantle minerals under high-pressure and high-temperature conditions. The experiments revealed that iron migrates into the mineral phase only in the presence of water (FIG. 1). Furthermore, the thickness of the iron-rich reaction layer was found to increase with the water content in the sample, highlighting the critical role of water in facilitating iron transport.

In the present experiments, a chemical reaction between water and iron led to the formation of ferropericlase via the reaction:

$$3Fe + H_2O \rightarrow FeO + 2FeH.$$

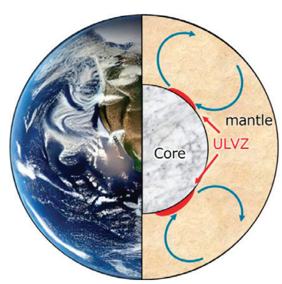


**FIGURE 2** Schematic illustration of ULVZ formation through iron–water exchange.

This reaction initiates the growth of the FeO-rich layer through water-induced iron oxidation (hereafter referred to as iron–water exchange). The diffusivity of iron in ferropericlase is known to be several orders of magnitude higher than in silicate minerals. In the actual mantle, ferropericlase formed through iron–water exchange could lead to iron enrichment over several kilometers at the base of the mantle in the presence of water (FIG. 2). These findings provide a plausible explanation for the seismic signatures observed in ULVZs, supporting a model of whole-mantle convection accompanied by deep water cycling from the crust to the core throughout Earth's history (Nishi et al. 2014).

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### REFERENCES

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