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論文要旨

THESIS SUMMARY

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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

In Chapter I, geophysical and geochemical approaches for investigating water in the Earth's interior are briefly reviewed. The aim of this study is to consistently characterize the roles of water in these processes, especially subducting slab physics and mantle geochemical evolution, based on these approaches.

In Chapter II, the effects of water on subduction dynamics, e.g., the plate migration rate, slab geometry, stress field, and back-arc spreading, are investigated using a 2-D self-consistent model for lithosphere subduction and whole-mantle convection. Here, the author models water transportation coupled with hydrous mineral phase changes. Interactions of mantle flows and water transportation are simulated using constitutive and state equations for hydrous rocks. The model has successfully reproduced water distribution in a mantle wedge and along the slab with sufficient resolution comparable to that of previous models focused on mantle wedge structure. Lower density of the subducting slab due to hydration decreases subduction rates, back-arc spreading, and slab stagnation at the phase boundary at 660-km depth. In contrast, low viscosity owing to hydration enhances rapid subduction, trench migration, and slab stagnation. Thus, water is capable of generating two opposite situations in terms of the stress field of the overlying lithosphere and the subduction rate, depending on the temporo-spatial distribution of density and viscosity variations. Therefore, the geodynamic effects of water may generate a broad range of subduction structures and dynamics, as observed in actual subduction zones such as Tonga and Mariana. Variation in buoyancy corresponding to the water content of the mantle wedge and slab surface, from relatively dry to several thousand parts per million, may account for the observed variations, although extremely buoyant cases do not seem to occur in nature. Water in the mantle is therefore key to better understanding whole-mantle-scale slab dynamics as well as island-arc volcanic processes.

In Chapter III, the fractionation, advection, and radioactive decay of U, Th, Pb, Rb, Sr, Sm, Nd, and several imaginary trace elements in both the solid and aqueous fluid phases are incorporated into the numerical model described in Chapter II. The simulation results reproduce the dehydration of oceanic crust and the overlying serpentinite, as well as the corresponding extraction of hydrophile elements in the mantle wedge. Aqueous fluids bearing the incompatible elements ascend toward the base of the overlying continental plate. However, the spatial distribution of chemical heterogeneity with variable degrees of depletion generated in this process is limited to the region around the subducting slab. The depleted materials sink to and accumulate at the bottom of the mantle because of their high density and viscosity. This process may be the origin of the hidden reservoir with extremely high Pb isotopic ratios. In contrast, the simulation shows that the dehydration of hydrous ringwoodite just below the 660-km discontinuity causes efficient propagation of hydrophilic heterogeneity. The boundary functions as a filter for water and hydrophiles carried by penetrating oceanic slabs, and causes accumulation of hydrous ringwoodite enriched in hydrophiles along the bottom of the transition zone. In contrast, depleted residues are continuously generated at 660 km and sink into the lower mantle. Because the chemical heterogeneity around 660 km is located in a hotter, less viscous region, it can propagate widely within a short period of time. The hydrous ringwoodite bodies above 660 km occasionally generate hydrophile-rich wet plumes because of the low density of the hydrous ringwoodite. We consider wet plumes from the 660-km discontinuity during continental convergence as a possible origin of hemispherical isotopic heterogeneity because continental collision, i.e., trench advance, and slab penetration at 660 km depth tend to occur simultaneously. This study shows that simultaneous modeling of geodynamics and geochemistry is a powerful approach for relating multiple observations.

In Chapter IV, the conclusions of this research are summarized. These findings emphasize the importance of integrating geodynamics and geochemistry.

備考 : 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

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