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論文審査の要旨及び審査員

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論文審査の要旨（2000字程度）

The student submitted a thesis titled "How Are the Core and Mantle Speaking to Each Other? A Hybrid Approach Towards Core-Mantle Interaction" which consists of five chapters:
Chapter 1: "Introduction" reviews previous work on core-mantle chemical interactions, and introduces the new ideas of the thesis. The background of geochemical evidence for core-mantle interaction is comprehensively reviewed, including a large array of element and isotope ratio. Basic chemical and physical considerations are then reviewed, before turning to a thorough review of all previously published ideas regarding physical mechanisms that could be responsible for explaining the geochemical signatures. Finally, a new "hybrid mechanism" is proposed that results from a non-linear collaborative feedback between simpler mechanisms.
Chapter 2: "The Hybrid Mechanism in an Isoviscous Mantle" presents a detailed analysis and basic models of the newly proposed hybrid mechanism for core-mantle interaction. The mechanism results from depression of the solid mantle into the core due to viscous stresses generated by large-scale mantle convection (so-called "dynamic topography"), decompaction and infiltration of metal into the submerged rock driven by pressure gradients, and gravitational collapse of the resulting metal-rock mixture owing to rheological weakening that results from metal intrusion. Since the dynamic topography is maintained by large scale convection, the gravitational collapse drives a secondary "collapse-driven flow" that increases the flux of rock into the metal-rock mushy layer. Numerical models of this process are constructed by decomposing the governing equations into a large-scale convection part driven by thermal buoyancy and a collapse-driven part which is calculated using an analytical expression from lubrication theory. The relative increase in rock-metal interaction in such a mush is then analyzed and scaling laws are derived that explain the numerical results.
Chapter 3: "The Hybrid Mechanism in a Variable Viscosity Mantle" considers the same mechanism, while allowing for temperature-dependent viscosity. Such an effect softens the deepest part of the mantle and the collapse-driven flow is more restricted to the thermal boundary layer.
Chapter 4: "Tracking Composition" presents the results of numerical models in which tracer particles are introduced in the rocky material and those that interact with metal in a mushy zone are tracked as they move through the model. It is also considered that the chemical reaction of the metal and rock changes the rock density, and the buoyancy effects are also included. It is shown that reactions producing denser rock tend to cause accumulations of reacted materials at the CMB beneath upwelling plumes, which may provide an alternative mechanism for some seismologically observed features in the core-mantle boundary region.
Chapter 5: "Conclusion and Future Steps" gives a summary of the new work and prospects for future studies, including more detailed work on the micro-physical process as well as the participation of dynamics on the core side.
In summary, this thesis presents genuine new ideas and valuable contributions to understanding core-mantle chemical interactions, with new innovations in modeling techniques. Therefore, the degree of Doctor of Science is deemed appropriate.