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論 文 要 旨

THESIS SUMMARY

専攻： Department of	地球惑星科学　　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（　理学　）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Large scaled chemical differentiation process at the early stage of the Earth's history such as core formation and crystal fractionation during solidification of magma ocean may have produced some sort of chemical heterogeneity in the Earth's mantle. Because such chemical differentiation processes involve crystal-melt element partitioning, precise knowledge of partition coefficient is essentially important for constraining the composition of the Earth's interior. In my Doctoral Thesis, I have studied element partitioning between mantle minerals and silicate melt under various conditions (pressure, temperature, water content) and general rules that govern changing PC-IR diagrams were investigated. I have also studied the behavior of hydrogen between Fe-metal (core) and silicate minerals (mantle) in the early differentiation stage.

In Chapter 2, pressure dependences of partition coefficients for trace elements between olivine and melt were investigated in order to evaluate the fractionation process in deep magma ocean. Results show clear pressure dependence on PC (partition coefficient)-IR (ionic radius) diagram. The PC-IR curve became wider with pressure increase, which means decrease of apparent Young's modulus E in lattice site. The observed decrease in E of the M-site (width of the parabola increases with pressure) cannot be explained by the pressure and temperature effects on the crystal structure, because the apparent softening of a crystal site at high pressures is hard to reconcile with a change in crystal structure. We suggest that this effect may be explained by considering the effect of silicate melt at pressures that may increase the apparent "Young's modulus of the M-site in the melt"

In Chapter 3, element partitioning between minerals (garnet, olivine) and coexisting hydrous silicate melt were determined in various water contents. The effects of water on partition coefficients for trivalent cations (Ga, Sc, REEs) were examined using PC-IR diagram and lattice strain model. The obtained parameters, the optimum ionic radius r_0 and the apparent Young's modulus E, which control the axis and width of PC-IR curve, were little affected by water. The difference of partition coefficients between hydrous and anhydrous systems can be explained by the effect of water on melting temperature. This result suggests that we can apply parameters (r_0, E) obtained from dry experiments to hydrous condition. Although the parameters were constant in various water contents, the shape of PC-IR curve, the absolute value D_0, change significantly because of the large decrease in melting temperatures by the presence of water.

In Chapter 4, I investigated partition coefficients between majorite-garnet and peridotite melt at 15-20GPa. Comparing with previous data, I found continuous decrease of partition coefficients for refractory lithophile elements such as Sc, REEs and Hf up to 25GPa. One of the factors causing the change of partition coefficients is the decrease on apparent Young's modulus E for X-site in garnet. The observed decrease of E in X-site of majorite garnet and that in M-site of olivine (chapter 2) cannot be correlated to the increase of bulk moduli of these crystals, but the decrease of E could be related to the differences in bulk moduli of crystals and melt. We estimated the apparent Young's moduli E for MgPv-melt and CaPv-melt constructed PC-IR diagrams at deep lower mantle conditions.

In chapter 5, I discussed chemical evolution of terrestrial magma ocean using obtained partition coefficients at each pressure in chapter 2-4. The calculation is based on bottom up fractional crystallization model. We divided the magma ocean into 132 layers, and calculated partitioning of refractory lithophile elements between a layer with residual magma ocean at each steps. The calculations are started from whole melted state of CI chondrite like bulk silicate earth (BSE) and peridotite like bulk silicate earth, respectively. Fractionations of 0.7% of protocrust and 10% of deep crystal pile from the convecting mantle based on peridotitic BSE composition is found to be consistent with observed ratios

of refractory lithophile elements in primitive upper mantle. Based on this model, I estimated Sm/Nd and Lu/Hf isotope ratio of hadean mantle.

In Chapter 6, hydrogen partitioning between metal and silicate and melting of iron-hydride FeH_X were investigated at 15GPa and 20GPa by high pressure experiments. Melting phase relation and hydrogen contents in FeH_X were determined from X-ray observation. Hydrogen contents in silicate (wadsleyite and ringwoodite) were determined using FT-IR. Our results show the decrease of melting temperature of iron by dissolution of hydrogen. Hydrogen strongly partitions to fccFe rather than wadsleyite and ringwoodite (D_H(γFeHx/Wd) = 206 ± 7 and D_H(γFeHx/Rw)= 229 ± 58). The partitioning behaviors indicate that hydrogen is partitioned into iron (core) than all of mantle minerals at deep mantle conditions. These results indicate a possibility that water reacted completely to form iron hydride at deep part of accreting planets and the iron hydride melted at temperatures significantly below that of surrounding dry silicate. If such reaction occurred at Mars sized undifferentiated planet with 2% H_2O in bulk, hydrogen content of the core would amount to be X=0.24.