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Phase relations of Earth's core materials

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Knowledge of thermodynamic state of the Earth's core is of primary importance for understanding the evolution of the solid Earth. In addition to iron which is its major component, several amounts of nickel and light element(s) should also be present in the core. I will review phase relations of these systems from recent high-pressure (P) and –temperature (T) experiments and thermodynamic modeling. First, I will introduce recent technical development of the so-called resistive internally heated diamond anvil cell (DAC) experiments in which thin iron (alloy) foil serves as a heater and a sample simultaneously. By resistance heating, it produces much more stable heating than the laser-heating technique and much higher temperature than the external-heating system. With this technique we conducted high-P-T in-situ measurements of the gamma-epsilon transitions in Fe and Fe-Ni alloy. In addition, I will also present new data of phase relations of Fe-Si alloy for which consistent phase relations have not been established so far. Next, thermodynamics of the core materials will be discussed based on the latest static high-P-T experiments. I constructed a thermodynamic model of melting relations in the system Fe-FeO to the outer core-inner core boundary (ICB) pressure. At the ICB pressure, calculations assuming the ideal solution for liquids show that the eutectic temperatures are much lower than results of DAC experiments showing a solid assemblage Fe+FeO at the same P-T conditions. Then, non-ideality of mixing for liquids was assessed to make the eutectic temperature consistent with the experiments. With the new solution model, the eutectic compositions under the core pressures are calculated. From the Gibbs free energy for the Fe-FeO liquids, I calculate the density, sound velocity, and adiabatic temperature profile of a hypothetical oxygen-bearing outer core. On the basis of these results, I will discuss if oxygen can be a major light element in the core or not.