Liquid immiscibility of Fe-FeO-FeS system at high pressure

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1. Introduction

Seismic observation and high-pressure experiments of iron indicate that the Earth's core is less dense than Fe at high-pressure condition (e. g., Anderson and Issak, 2002), suggesting that the core contains several percent of light elements. It is important to investigate what kind of elements and how much amounts are contained in the core in order to constrain the evolition and the dynamics of the Earth. The candidates of the light elements are S, Si, O, H, and C (e. g., Porier, 1994). In this study, we focused on O and S. They are likely to exist in the core because O is abundant in the terrestrial planets and S is depleted in the mantle (Murthy and Hall, 1970) and is constrained in the meteorites. Previously, high-pressure experiments in the Fe-FeO-FeS system were conducted by Urakawa et al.,(1987), who reported that the liquid immiscible region narrowed with increasing pressure up to 15GPa. We carried out the experiments in this system and determined the liquid immiscible region from 15-21GPa.

2. Experimental procedure

High-pressure experiments were performed using Kawai-type multianvil apparatus installed in Tohoku University. ZrO2 as pressure medium and LaCrO3 as heater are used, and temperature was measured using a W3%Re-W25%Re thermocouple. Starting materials were a mixture of Fe (99.9% pure), FeS (99.9% pure), Fe0.91O (reduced from Fe2O3 hematite), and they are enclosed in an Al2O3 capsule. First, samples were compressed to the desired pressure, and then heated. After keeping for 1-3 minutes at the desired temperature, samples were quenched by shutting off the power, and then decompressed. Recovered samples were analyzed by SEM, and melting was judged from the quenched texture. We measured the compositions of the immiscible two liquids using the wave-dispersive EPMA.

3. Results

Starting compositions were (1) 88.1wt.%Fe- 11.9wt.%O, (2) 88.0wt.%Fe- 11.0wt.%O- 1.0wt.%S, (3) 87.5wt.%Fe- 10.7wt.%O- 1.8wt.%S, (4) 87.1wt.%Fe- 10.3wt.%O- 2.6wt%S, and (5) 83.8wt.%Fe- 8.7wt.%O- 7.5wt.%S. We determined the liquidus temperature at 15GPa-2200oC, 18GPa-2300oC, 21GPa- 2500oC using the composition of (1) (Fe-FeO system), and investigated the closure of the immiscible two liquid by adding sulfur in these pressure-temperature conditions. At 15GPa and 2200oC, the immiscible two liquids were observed using (1), (2), (4) compositions, whereas miscible one liquid using (5). At 18GPa and 2300oC, the immiscible two liquids were observed using (1), (2), (3) and miscible one liquid using (4). At 21GPa and 2500oC, the immiscible two liquids were observed using (1) and miscible one liquid using (3). It is expected that the liquid immiscible region narrow with increasing pressure. The detail analysis using the wave-dispersive EPMA is now in progress, and we will report the liquid immiscible region in these pressure range.